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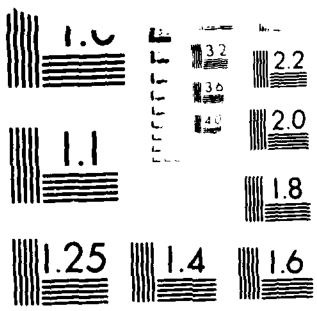
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VOLUME 1 OF 2

(2)

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INSTALLATION RESTORATION PROGRAM
PHASE II - CONFIRMATION/QUANTIFICATION

STAGE 2

REPORT FOR

MATHER AIR FORCE BASE,
SACRAMENTO, CALIFORNIA

AEROVIRONMENT INC.
825 MYRTLE AVENUE
MONROVIA, CALIFORNIA 91016

JUNE 1987
FINAL (SEPTEMBER 1985 TO JUNE 1987)

APPROVED FOR PUBLIC RELEASE
DISTRIBUTION UNLIMITED

PREPARED FOR

HEADQUARTERS AIR TRAINING COMMAND
COMMAND SURGEON'S OFFICE (HQATC/SGPB)
BIOENVIRONMENTAL ENGINEERING DIVISION
RANDOLPH AFB, TEXAS 78150-5001

UNITED STATES AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY (USAFOEHL)
TECHNICAL SERVICES DIVISION (TS)
BROOKS AIR FORCE BASE, TEXAS 78235-5501

AV-FR-86/501

INSTALLATION RESTORATION PROGRAM
PHASE II - CONFIRMATION/QUANTIFICATION

STAGE 2

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MATHER AIR FORCE BASE,
SACRAMENTO, CALIFORNIA

HEADQUARTERS AIR TRAINING COMMAND
COMMAND SURGEON'S OFFICE (HQATC/SGPB)
BIOENVIRONMENTAL ENGINEERING DIVISION
RANDOLPH AFB, TEXAS 78150-5001

JUNE 1987

PREPARED BY

AEROVIRONMENT INC.
825 MYRTLE AVENUE
MONROVIA, CALIFORNIA 91016

USAF CONTRACT NO. F33615-83-D4000, DELIVERY ORDER No. 10
AEROVIRONMENT PROJECT NO. 10416J

APPROVED FOR PUBLIC RELEASE
UNLIMITED DISTRIBUTION

CAPTAIN BRIAN D. McCARTY
USAFOEHL TECHNICAL PROGRAM MANAGER

UNITED STATES AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY (USAFOEHL)
TECHNICAL SERVICES DIVISION (TS)
BROOKS AIR FORCE BASE, TEXAS 78235-5501

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This report has been prepared for the United States Air Force by AeroVironment Inc., for the purpose of aiding in the implementation of the Air Force Installation Restoration Program. It is not an endorsement of any product. The views expressed herein are those of the contractor and do not necessarily reflect the official views of the publishing agency, the United States Air Force, nor the Department of Defense.

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

AeroVironment Inc. was tasked to conduct a Phase II, Stage 2 IRP survey at Mather AFB in Sacramento, California. The objective of this survey was to confirm and quantify the presence and extent of contamination at 15 sites: Drainage Ditch No. 1 and No. 2, Weapons Storage Area, Landfill No. 1, Firing Range Landfill, 8150 Landfill, Runway Landfill, Landfill No. 3, Landfill No. 2, existing Fire Protection Training Area (FPTA), FPTA No. 1 and No. 3, MOGAS Spill, Old Burial Site and Fuel Tank Sludge Burial Pit. Twenty-eight groundwater monitoring wells were drilled and installed (using air rotary with casing hammer for drilling and either PVC or steel well materials). The wells were each sampled twice and analyzed for volatile organics and other constituents. Soil samples were collected from four locations at two of the sites. Also, geophysical surveys were conducted at eight of the sites.

The soil samples were not found to be contaminated. The groundwater sample analyses showed that the groundwater at 15 of the 28 wells contained the following solvents: trichloroethylene (TCE), tetrachloroethene (PCE), trans-1,2-dichloroethene (DCE), 1,2-dichloropropane. Nine wells showed concentrations exceeding state action levels. PCE was found in the northeast corner of the base and TCE was found in the northwest corner. Twelve new wells are recommended to help monitor conditions (1) upgradient of sites and (2) in deeper aquifers downgradient from sites. Additional sampling for volatile organics is required at contaminated wells.

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PREFACE

This report was prepared by AeroVironment Inc. under task order 10 of contract F33615-83-D-4000. This report is a summary of field activities, data, analysis, conclusions and recommendations prepared as part of the Phase II, Stage 2 IRP investigation of Mather AFB.

The project team primarily consisted of Mr. Douglas Taylor, Mr. Timothy O'Gara, Mr. Christopher Lovdahl and Ms. Sheryl Thurston of AeroVironment Inc. Mr. Taylor served as project manager, Mr. O'Gara served as field geologist, Mr. Lovdahl provided laboratory coordination, and Ms. Thurston assisted with drilling and sampling.

AeroVironment wishes to acknowledge the assistance of Mather AFB personnel, particularly Capt. James Curran, and MSgt. Patricia Sparks of the Bioenvironmental Engineering office. Also, the Phase I report prepared by CH2M Hill and the Phase II, Stage 1 report prepared by Roy F. Weston were used as information sources throughout this project.

This work was accomplished between September 1985 and June 1986. Lt. Col. Edward Barnes and Capt. Brian D. McCarty, Technical Services Division, USAF Occupational Environmental Health Laboratory (USAFOEHL) were the technical monitors.

Approved:

Ivar H. Tombach
Vice President, Environmental Programs Division

Douglas B. Taylor, P.E.
Project Manager

REGISTERED PROFESSIONAL ENGINEER
DOUGLAS B. TAYLOR
37816
CIVIL
STATE OF CALIFORNIA

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EXECUTIVE SUMMARY

The United States Air Force has developed the Installation Restoration Program to assess the environmental effects of past hazardous material handling and disposal activities. As part of that program, the Air Force assigned task order No. 10 to AeroVironment Inc., under contract No. F33615-83-D-4000, to conduct a Phase II, Stage 2 study of Mather AFB, California. Mather is located about 15 miles east of downtown Sacramento, in Rancho Cordova, California.

A Phase II study, using a staged approach, is intended to confirm the presence or absence of contamination at sites reported in the Phase I report (a record search) and to quantify the presence and extent of contamination which may be present. At Mather, a Phase II, Stage 1 study, which investigated the three highest priority sites, was already completed. The Phase II, Stage 2 was conducted to investigate 15 additional sites which were identified but were not recommended for immediate investigation. A base map showing Stage 2 sites is included in the text as Figure I-3. AeroVironment was assigned the following sites as part of Phase II, Stage 2:

Site	13	Drainage Ditch Site No. 1
Site	14	Drainage Ditch Site No. 2
Site	17	Weapons Storage Area Septic Tank
Site	4	Northeast Perimeter Landfill No. 2
Site	11	Existing Fire Protection Training Area (1958-1984)
Site	8	Fire Protection Training Area No. 1
Site	10	Fire Protection Training Area No. 3
Site	3	Northeast Perimeter Landfill No. 1
Site	6	Firing Range Landfill Sites
Site	2	"8150" Area Landfill
Site	20	MOGAS Spill Site
Site	1	Runway Overrun Landfill
Site	18	Old Burial Site
Site	19	Fuel Tank Sludge Burial Site
Site	5	Northeast Perimeter Landfill No. 3

In particular, AeroVironment was asked to drill, install and sample 28 groundwater monitoring wells at these 15 sites (these wells are shown on Figure I-3 of this report). Geophysical surveys were conducted at eight of the sites to help evaluate

site boundaries and detect any contaminant plumes which may have been encountered. Limited soil sampling was also completed at Sites 10 and 19.

The drilling method for the groundwater wells was air rotary with casing hammer drive. Wells were constructed of PVC or stainless steel and were screened in the first water encountered.

History of Sites

Mather Air Force Base was constructed in 1918 and served as a flight training school until 1922. Mather was operated sporadically from 1922 to 1941, at which time the base was redesigned for pilot and navigator training. Mather served various roles from 1941 until the current time. Since 1963, the major tenant organization has been the 320th Bombardment Wing.

Drainage Ditch No. 1 is an unlined culvert which, for about 13 years, received runoff from the aircraft washrack operations. Drainage Ditch No. 2 is also an unlined culvert which reportedly had waste oils and solvents dumped directly into it. The Weapons Storage Area has a septic tank and had no sanitary sewer until 1978. It was suspected that small amounts of waste solvent had been disposed into the tank.

Northeast Perimeter Landfill No. 2 was the main sanitary landfill from 1967 to 1971. A petroleum, oil and lubricant (POL) waste pit was part of this landfill. The most recently operated Fire Protection Training Area (FPTA) was used for fire training until 1984. Waste fuel was floated on water, ignited and extinguished in an unlined pit. FPTA No. 1 was used for the same purpose as the existing FPTA during the years the base was in operation from 1918 to 1945. FPTA No. 3 was used from 1947 to 1958 for daily fire training. NE Perimeter Landfill No. 1 was the main sanitary landfill for Mather AFB from 1950 to 1967. POL waste was probably not placed into this landfill in significant quantities.

The Firing Range Landfill was used as the main sanitary landfill from 1972 to 1974. Some POL waste may have been sent to this site. The "8150" Area Landfill

served as the main sanitary landfill from 1942 to 1950. It is suspected that POL waste was placed in this landfill. The MOGAS (motor vehicle gasoline) Spill Site consists of a single MOGAS tank which is reported to have leaked 700 gallons of leaded gasoline.

Runway Overrun Landfill was the base landfill prior to 1942. No significant POL waste was placed there. The Old Burial Site was used for disposal of a variety of items and was used as a landfill in the late 1940s. The Fuel Tank Sludge Burial Site was used for burial of tank bottom sludge from JP-4 and AVGAS tanks. The NE Perimeter Landfill No. 3 was used as a base landfill during 1971. No significant POL disposal is suspected.

Testing Conducted

AeroVironment and its geophysical subcontractor performed geophysical testing at eight sites during the period September 23-27, 1985. Drilling began on September 30, 1985 and was completed on November 8, 1985. At least one AeroVironment geologist was on site during all of these activities. Soil samples were collected from Site 10 in December 1985 and from Site 19 in January, 1986.

Two complete sets of groundwater samples were collected from each of the 28 wells installed during this program. The samples were collected in December 1985 and January 1986. Some wells were resampled in March 1986 in order to complete the data set. A summary of the work completed during this project is shown in Table ES-1.

Summary of Results

Results from the geophysical testing were used to properly place groundwater monitoring wells. In several cases we determined that previously reported boundaries for sites were incorrect. The results of the soil sampling indicated that there is no contamination in the shallow soils at either Site 19 or 10. Groundwater flow is from northeast to southwest.

TABLE ES-1. Summary of completed activities.

Site No.	Site Name	No. of Monitoring Wells*	Groundwater Sampling Parameters	Soil Samples	Geophysical Survey
13	Drainage No. 1	1	VOA, O&G	--	--
14	Drainage No. 2	2	VOA, O&G	--	--
17	Weapons Storage	1	VOA, O&G, Cl^- NO_2^-, $SO_4^=$	--	--
4	Landfill No. 2	3	VOA, O&G, DBCP, EDB, Pb	--	Yes
11	Existing FPTA (1958 - 1984)	1	VOA, O&G, DBCP EDB, Pb	--	--
8	FPTA No. 1	1	VOA, O&G, DBCP EDB, Pb	--	Yes
10	FPTA No. 3	2	VOA, O&G, DBCP EDB, Pb	6; Same parameters as water	Yes
3	Landfill No. 1	3	VOA, O&G, Cl^- NO_2^-, $SO_4^=$	--	Yes
6	Firing Range	3	VOA, O&G, Cl^- NO_2^-, $SO_4^=$	--	--
2	8150 Landfill	3	VOA, O&G, Cl^- NO_2^-, $SO_4^=$	--	--
20	MOGAS Spill	1	VOA, O&G, DBCP, EDB, Pb	--	Yes
1	Runway Landfill	2	VOA, O&G, Cl^- NO_2^-, $SO_4^=$	--	Yes
18	Old Burial	1	VOA, O&G, DBCP EDB, Pb	--	--
19	Fuel Tank Sludge Burial Site	2	VOA, O&G, DBCP EDB, Pb	6; Same parameters as water	Yes
5	Landfill No. 3	2	VOA, O&G, Cl^-, NO_2^-, $SO_4^=$	--	Yes

*Each sampled twice

VOA = Volatile organic analysis, O&G = oil and grease, Cl^- = chloride ion, NO_2^- = Nitrate ion, $SO_4^=$ = sulfate ion, DBCP = dibromochloropropane, EDB = ethylene dibromide, Pb = Lead

Water samples were analyzed for the parameters shown in Table ES-1. Only four compounds were identified in significant concentrations in any of the groundwater samples; trichloroethene (TCE), tetrachloroethene (PCE), 1,2-trans-dichloroethene (DCE) and 1,2-Dichloropropane. Significant concentrations have been generally determined to be (1) repeatable in both sample sets and (2) in concentrations greater than the level of quantification (defined as ten times the detection limit).

Fifteen of the 28 wells were found to contain significant concentrations of one or more of the solvents listed above. Groundwater from nearly all wells in the northeast corner of the base contained PCE. DCE, TCE and, to a lesser extent, 1,2-Dichloropropane are also present in the same area. Nine wells (out of 12 in this area) exceed the California Department of Health Services action level for PCE. Sites in this area of the base are NE Perimeter Landfills No. 1, 2 and 3, Drainage Ditch No. 1, FPTA No. 1 and the Runway Overrun Landfill. Although contamination has been found throughout this area of the base, the source(s) are not known. Of particular importance is the lack of upgradient samples to determine if the problem is being caused in whole or in part by off-base sources.

Samples from several wells in the northwest corner of the base (northwest of the flightline) were found to contain TCE. Four of seven wells were found to contain significant concentrations of TCE. Two wells exceed the California Department of Health Services action level for TCE, including one well located immediately upgradient from two base production wells.

Stream channel deposits under the northwest corner of the base are thought to provide pathways for the movement of contaminant and thus may be an important factor in the movement of contaminants. Generally speaking, contaminated wells are in the stream deposits and uncontaminated wells are not in the deposits. Off-base wells which have reported TCE problems are also located in the stream channel deposits. Two factors to consider in determining the source of the TCE contamination are: (1) no upgradient wells exist to determine if water is contaminated as it enters the base, and (2) several known sites with a history of TCE problems in groundwater are located upgradient from Mather AFB, above the same channel deposit that intercepts Mather AFB.

Samples from monitoring wells in the southern part of the base showed no contamination.

Conclusions and Recommendations

Groundwater contamination has been found at two areas of Mather Air Force Base. The northeast corner of the base has PCE (primarily) contamination which may be the result of dumping at one or more sites in that area. However, no upgradient sampling was conducted and off-base sources cannot be ruled out. Additional wells are required to investigate upgradient conditions and downgradient conditions in deep aquifers.

The northwest corner of the base is underlain with stream channel deposits which provide pathways for rapid movement of groundwater (and contaminants). TCE was found in several wells drilled into these deposits. Additional wells are needed to determine if the TCE is from upgradient, off-base sources or from sites in the northwest corner of the base. Deep wells are also needed to check conditions in lower aquifers near base production wells.

No problems were found with sites located in the southern portion of the base. No further monitoring is recommended in this area at this time.

Specific recommendations are summarized in Table ES-2.

TABLE ES-2. Summary of recommendations.

Site	Recommendation	Rationale
No. 2, "8150" Landfill	- No additional work is needed. However, the wells at this site may be useful monitoring locations for Sites No. 3, 4, and 5 at some time in the future.	- No evidence of groundwater contamination.
No. 3, Landfill No. 1	- Install 3 additional groundwater monitoring wells: 1 shallow up gradient 1 deep up gradient 1 deep down gradient - Sample 6 wells (3 existing and 3 proposed) semiannually, and test for VOAs (Method 601)	- The three existing wells were found to contain PCE at levels above the DOHS action level.
No. 4, Landfill No. 2	- Install 2 additional groundwater monitoring wells: 1 deep down gradient 1 shallow up gradient (replace MAFB-5) - Incorporate the Phase II, Stage 3 deep up-gradient well into the monitoring plan for this site. - Sample 6 wells (3 existing, 1 planned, 2 proposed) semiannually, and test for VOAs (Method 601)	- The three existing wells were *found* to contain PCE at levels above the DOHS action level. The DCE standard was exceeding in one well.
No. 5, Landfill No. 3	- Conduct a geophysical study (electrical conductivity) to trace the identified plume to its endpoint. - If the plume appears to extend beyond the existing monitoring well system, install an additional well to monitor the plume. - Sample the 2 existing wells semiannually, and test for VOAs (Method 601)	- The geophysical survey was not completed inside the fenced area. - One of the existing wells contained PCE, DCE and dichloropropane at levels below the DOHS action level.
No. 6, Firing Range LF	- No additional work is needed.	- No evidence of groundwater contamination.
No. 17, Weapons Storage	- No additional work is needed.	- No evidence of groundwater contamination.

TABLE ES-2. (cont'd)

Site	Recommendation	Rationale
No. 20, MOGAS Spill	- No additional work is needed.	- No evidence of ground-water contamination.
No. 11, Existing FPTA (1958-1984)	- No additional work is needed. However, MAFB-39 may be a useful monitoring location at some time in the future.	- No evidence of groundwater contamination.
No. 10(A&B), FPTA No. 3	- Sample the two wells at these locations semi-annually and test for VOAs (Method 601). - Conduct a geophysical survey (electrical conductivity) to define the magnetic anomoly identified here.	- The two existing wells were found to contain low levels of TCE. - The original geophysical survey could not define the bounds of the anomoly.
No. 19, Fuel Tank Burial	- No additional work is needed for this site (Use the wells at this site for monitoring Site No. 18).	- No evidence of ground-water contamination.
No. 18, Old Burial Site	- Install 2 additional groundwater monitoring wells: 1 deep up gradient 1 shallow up gradient - Sample 5 wells (1 existing, 2 from Site No. 19, 2 proposed) semiannually, and test for VOAs (Method 601).	- The existing well was found to contain TCE at a level 10 times greater than the DOHS action level.
No. 14, Drainage Ditch No. 2	- Install 3 additional groundwater monitoring wells: 2 deep down gradient 1 shallow up gradient - Incorporate the Phase II, Stage 3 deep up-gradient well into the monitoring plan for this site. - Sample 6 wells (2 existing, 1 planned, 3 proposed) quarterly and test for VOAs (Method 601).	- The existing wells were found to contain TCE at a level above the DOHS action level. - Site 14 is located upgradient from base supply wells MB-2 and MB-3.

TABLE ES-2. (cont'd)

Site	Recommendation	Rationale
No. 13, Drainage Ditch No. 1	- Sample the well at this location semiannually and test for VOAs (Method 601). - Drill 4 hollow stem auger borings to 40' and sample water if encountered. Analyze water for VOAs (Method 601).	- The existing well was found to contain PCE, TCE and DCE below the DOHS action level. - Perched water may exist under the site and would be important to pinpoint source(s).
No. 8, FPTA No. 1	- Install one additional shallow, up-gradient groundwater monitoring well between the site and the base boundary. - Sample 2 wells (1 existing, 1 proposed) semiannually, and test for VOAs (Method 601).	- The one existing well was found to contain PCE at a level above the DOHS action level, and TCE, DCE and 1,2-dichloropropane below DOHS action levels. - No good upgradient sampling location exists.
No. 1, Runway Landfill	- Install one additional deep groundwater monitoring well near MAFB-14 or 15. - Sample 2 wells (1 existing, 1 proposed) semiannually and test for VOAs (Method 601).	- The two existing wells were found to contain PCE at a level above the DOHS action level, and TCE, DCE and 1,2-Dichloropropane below the action levels.

I. INTRODUCTION

A. Purpose of the Program

The United States Air Force (USAF) has developed the Installation Restoration Program (IRP) to identify and evaluate environmental contamination from past handling and disposal of hazardous materials at Air Force Bases throughout the United States. AeroVironment Inc. (AV) was retained by the U.S. Air Force Occupational and Environmental Health Laboratory (USAFOEHL) to provide consulting services for the IRP under contract F33615-83-D-4000. Under that contract, AV was tasked to conduct a Phase II, Stage 2 investigation of Mather AFB, California for Headquarters Air Training Command (HQ ATC). The stated objectives of that task order were:

(1) To determine the presence or absence of contamination within the specified areas of investigation.

(2) If contamination exists, to determine the potential for migration of those contaminants in the various environmental media.

(3) To identify additional investigations necessary to determine the magnitude, extent, direction and rate of migration of discovered contaminants.

(4) To identify potential environmental consequences and health risks of migrating pollutants.

In the Phase I Record Search, 23 sites were identified as possible/known hazardous waste disposal sites at Mather AFB. Twenty of these sites were ranked using the hazard assessment rating methodology (HARM). The Phase I report recommended that the three highest ranked sites be investigated further in Phase II, Stage 1.

During the Phase II, Stage 2 Project, HQ ATC decided to investigate 15 of the remaining 17 ranked sites as well. The investigation of these 15 sites (along with the three from Stage 1) was intended to determine whether and to what extent they were impacting groundwater quality. The Phase II, Stage 2 sites are, in order of decreasing HARM ranking:

Site 13	Drainage Ditch Site No. 1
Site 14	Drainage Ditch Site No. 2
Site 17	Weapons Storage Area Septic Tank
Site 4	NE Perimeter Landfill No. 2
Site 11	Existing Fire Department Training Area (1958-1984)*
Site 8	Fire Department Training Area No. 1
Site 10	Fire Department Training Area No. 3
Site 3	NE Perimeter Landfill No. 1
Site 6	Firing Range Landfill Sites
Site 2	"8150" Area Landfill
Site 20	MOGAS Spill Site
Site 1	Runway Overrun Landfill
Site 18	Old Burial Site
Site 19	Fuel Tank Sludge Burial Site
Site 5	NE Perimeter Landfill No. 3

To meet these objectives, AV installed and sampled 28 groundwater monitoring wells at 15 sites throughout the base. At eight of the sites, AV conducted geophysical surveys to define the site boundaries and to help select well locations. AV also collected shallow soil samples from two of the sites, as a result of a magnetometer survey. Table I-1 summarizes the work that was planned for each of these sites.

-----

*Since the Phase I report release, a new fire training area has been constructed. However, to maintain consistent terminology with the Phase I report, the previous fire training area (Site 11) is still titled the "Existing Fire Training Area" in this report

TABLE I-1. Summary of planned activities.

Site No.	Site Name	No. of Monitoring Wells	Groundwater Sampling Parameters	Soil Samples	Geophysical Survey
13	Drainage No. 1	1	VOA, O&G	--	--
14	Drainage No. 2	2	VOA, O&G	--	--
17	Weapons Storage	1	VOA, O&G, Cl^- NO_2^-, $SO_4^=$	--	--
4	Landfill No. 2	3	VOA, O&G, DBCP, EDB, Pb	--	Yes
11	Existing FPTA (1958-1984)	1	VOA, O&G, DBCP EDB, Pb	--	--
8	FPTA No. 1	1	VOA, O&G, DBCP EDB, Pb	6; Same parameters as water	Yes
10	FPTA No. 3	2	VOA, O&G, DBCP EDB, Pb	6; Same parameters as water	Yes
3	Landfill No. 1	3	VOA, O&G, Cl^- NO_2^-, $SO_4^=$	--	Yes
6	Firing Range	3	VOA, O&G, Cl^- NO_2^-, $SO_4^=$	--	--
2	8150 Landfill	3	VOA, O&G, Cl^- NO_2^-, $SO_4^=$	--	--
20	MOGAS Spill	1	VOA, O&G, DBCP, EDB, Pb	--	Yes
1	Runway Landfill	2	VOA, O&G, Cl^- NO_2^-, $SO_4^=$	--	Yes
18	Old Burial	1	VOA, O&G, DBCP EDB, Pb	--	--
19	Fuel Tank	2	VOA, O&G, DBCP EDB, Pb	9; Same parameters as water	Yes
5	Landfill No. 3	2	VOA, O&G, Cl^-, NO_2^-, $SO_4^=$	--	Yes

VOA = Volatile organic analysis, O&G = oil and grease, Cl^- = chloride ion, NO_2^- = Nitrate ion, $SO_4^=$ = sulfate ion, DBCP = dibromochloropropane, EDB = ethylene dibromide, Pb = Lead

AV completed the work as specified in the project Statement of Work (SOW) and was able to accomplish the majority of the previously noted objectives. Some of the soil sampling was eliminated, as a result of the magnetometer survey, but all of the groundwater monitoring wells were installed and sampled. The results of the sample analyses, discussed in Chapter IV, have helped us determine which sites at Mather AFB show evidence of contamination.

B. Duration of the Program

The IRP Program began at Mather AFB with a Phase I Records Search conducted in March-June 1982 by CH2M Hill. In 1984, Roy F. Weston Inc. (Weston) conducted a Phase II, Stage 1 investigation limited to the three highest ranked sites identified in the Records Search. HQ ATC later decided to conduct Phase II investigations at additional sites identified in the Records Search. Weston conducted a Phase II, Stage 2 presurvey site visit at Mather AFB in January 1985 and prepared a preliminary Statement of Work to evaluate the 22 remaining sites. During the presurvey, regulatory and USAF personnel agreed that only 15 sites required additional investigation in this stage. Weston submitted a preliminary Statement of Work to USAFOEHL in February 1985. USAFOEHL requested that AV visit Mather AFB in May 1985 to become familiar with the 15 Phase II, Stage 2 sites. AV submitted comments to USAFOEHL on the preliminary Statement of Work and later cost estimates for completion of the proposed work. On September 3, 1985, AV received Task Order No. 10 of Contract F33615-83-D4000 to conduct the Phase II, Stage 2 survey at Mather AFB.

AV had requested and received bids from drilling and geophysical subcontractors prior to September 3, 1985. Upon receipt of the task order, we formalized the subcontracts and planned the logistics for beginning field work. The geophysical survey was conducted from September 23-27, 1985. Well drilling began on September 30, 1985 and finished on November 8, 1985. Soil samples were collected in December 1985 and January 1986. AV collected groundwater samples at three times throughout the project: December 2-8, 1985, January 11-15, 1986 and March 23-25, 1986. The last sampling trip collected samples again from the initial rounds, since holding times had been exceeded for the samples collected

during previous sampling events. All field work at Mather AFB was completed by March 25, 1986. All laboratory analyses were completed by April 9, 1986. Report preparation began after the well drilling was completed. This document is a summary of the findings, tasks and impact analysis performed under this investigation.

C. Base History

Mather Air Force Base (see Figures I-1 and I-2) was constructed in 1918 and served as a flight training school until June 1922 when it was inactivated. For a period between March 1930 and November 1932, Mather was reactivated, but it was not involved in continuous military activity until WWII. Upon final reactivation in 1941, the base was redesigned for pilot and navigator training. It officially resumed its training mission in 1945 with the first school established for navigator-bombardiers. This school has since been expanded to train all services under the Department of Defense. In 1958, Strategic Air Command assigned the 4134th Strategic Wing to Mather as a tenant organization. This wing was replaced by the current tenant organization, the 320th Bombardment Wing, in February 1963.

The following is a description of the sites which AV investigated for possible contaminants. Most of the information presented in this section has been taken from the Phase I Records Search. Location of these sites is indicated in Figure I-3. Specific locations of these sites will be presented in Chapter 4.

1. Drainage Ditch Site No. 1 (Site 13)

Drainage Ditch Site No. 1, located just north of the runway overrun, consists of an unlined open ditch leading into a culvert under the runway. From 1960 to 1973, the ditch received runoff from an aircraft washrack operation that included paint stripping and grease removal from B-52 and T-29 aircraft. The latter industrial process required the use of trichloroethene (TCE). In 1968, an oil skimmer was installed which accepted waste oils and solvents. The skimmer occasionally over-topped and flowed into the drainage ditch. Before the skimmer was installed, these wastes may have been poured directly into the ditch.

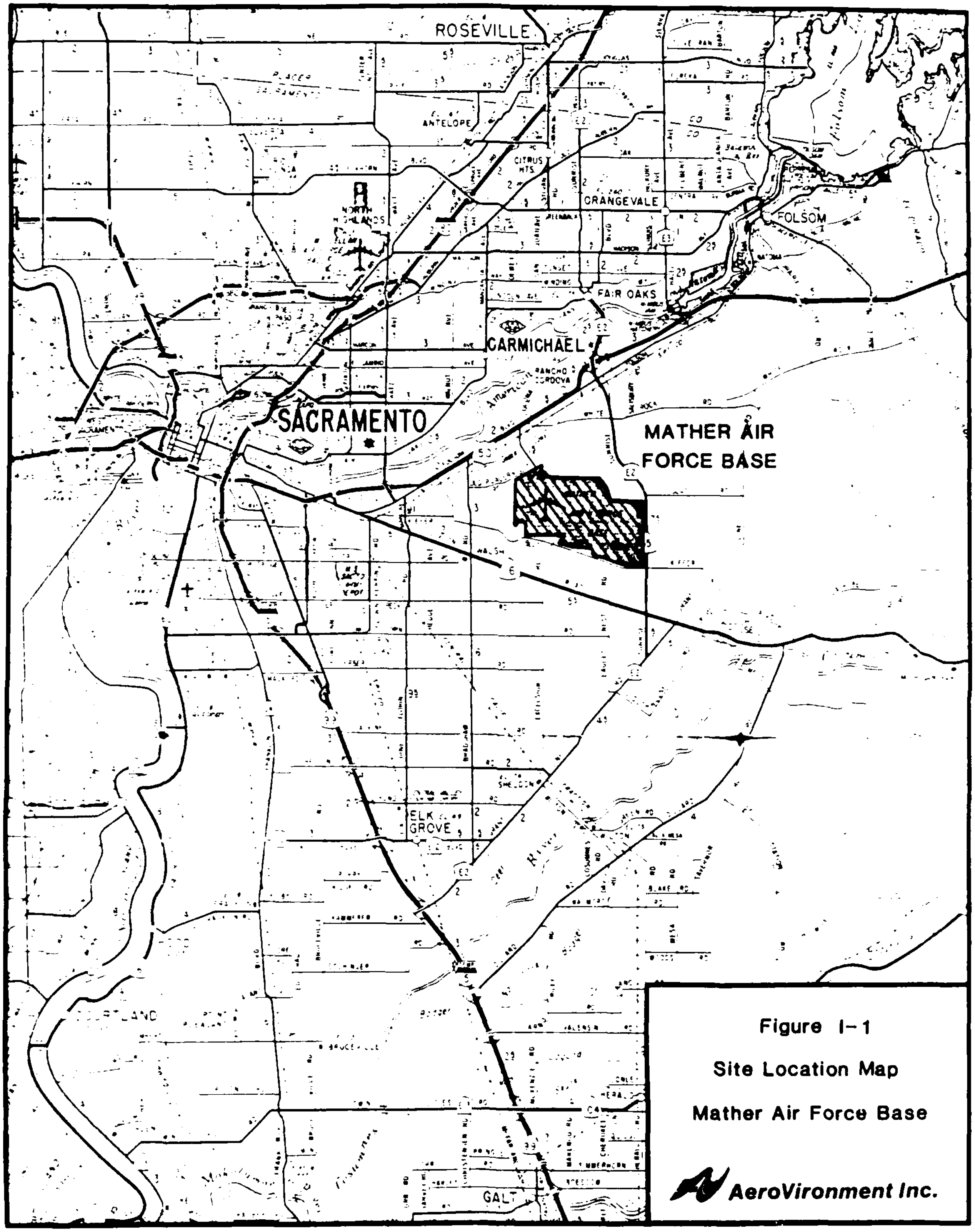


Figure I-1

Site Location Map

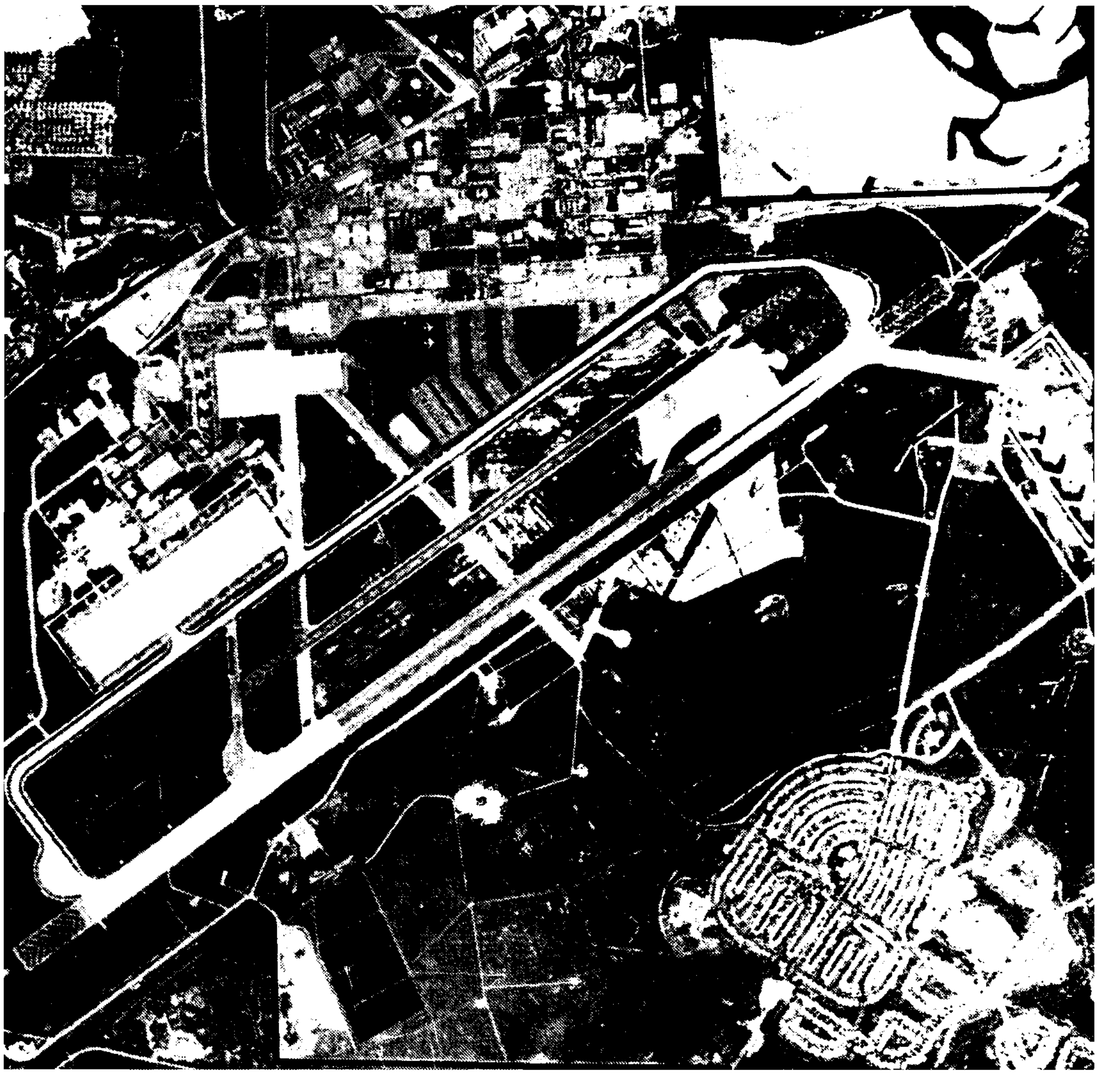
Mather Air Force Base

AeroVironment Inc.

March 1987

Approximate Scale: 1" Equals 4 Miles
Reference: Sacramento Valley Region Map
California State Automobile Association

87-78



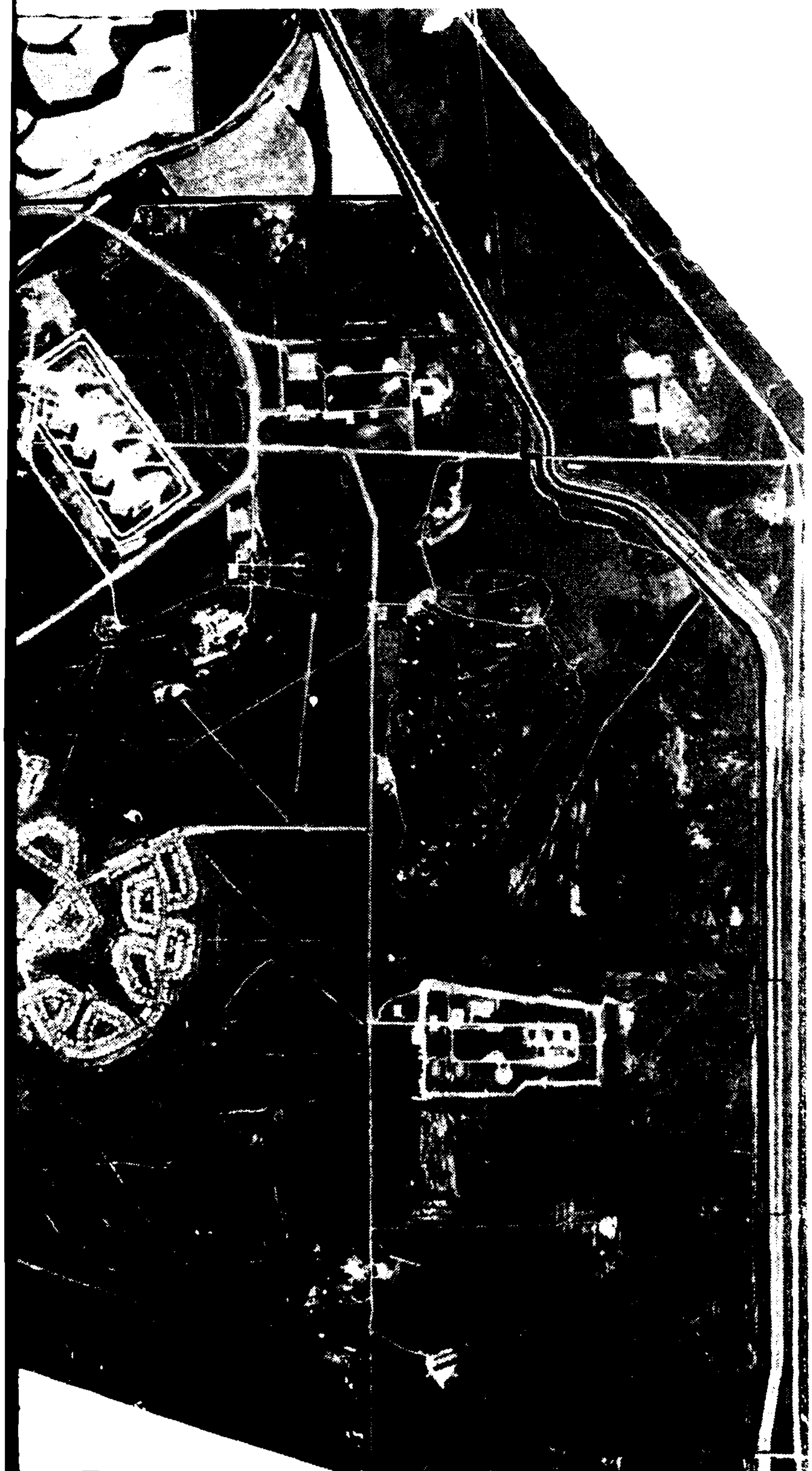


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Figure I-2
Base Photo
Mather Air Force Base

AeroVironment Inc.

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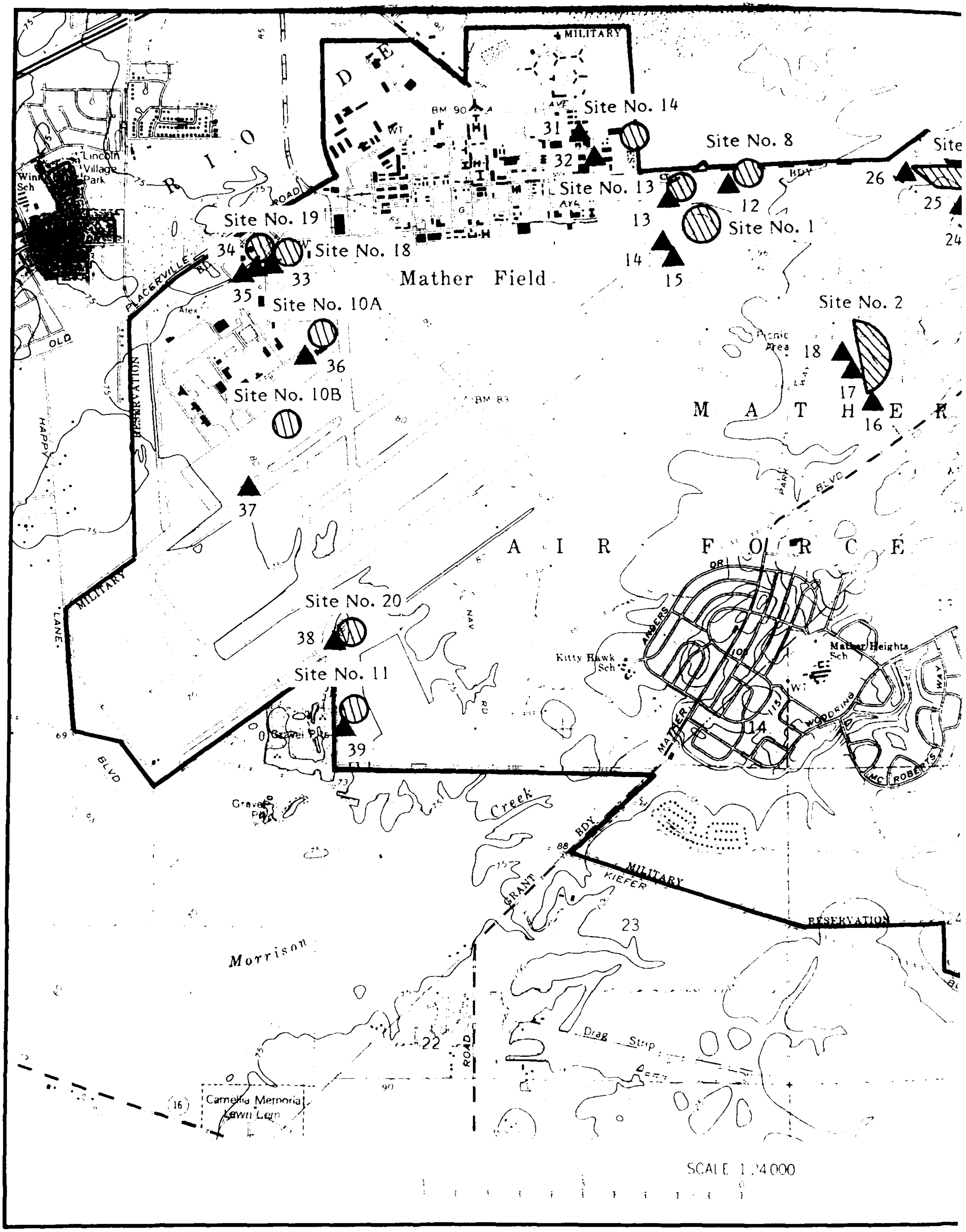

Site No. 14
Site No. 8
Site No. 13
Site No. 1
Site No. 19
Site No. 18
Mather Field
Site No. 10A
Site No. 2
Site No. 10B
M A T H E R
A I R F O R C E
Site No. 20
Site No. 11
Lincoln Village Park
Kitty Hawk Sch
Mather Heights Sch
Gravel Pits
Creek
Morrison
Drag Strip
Camellia Memorial Lawn Cem
MILITARY RESERVATION
PLACERVILLE RD
HAPPY LANE
KIEFER
GRANT
SCALE 1:24 000

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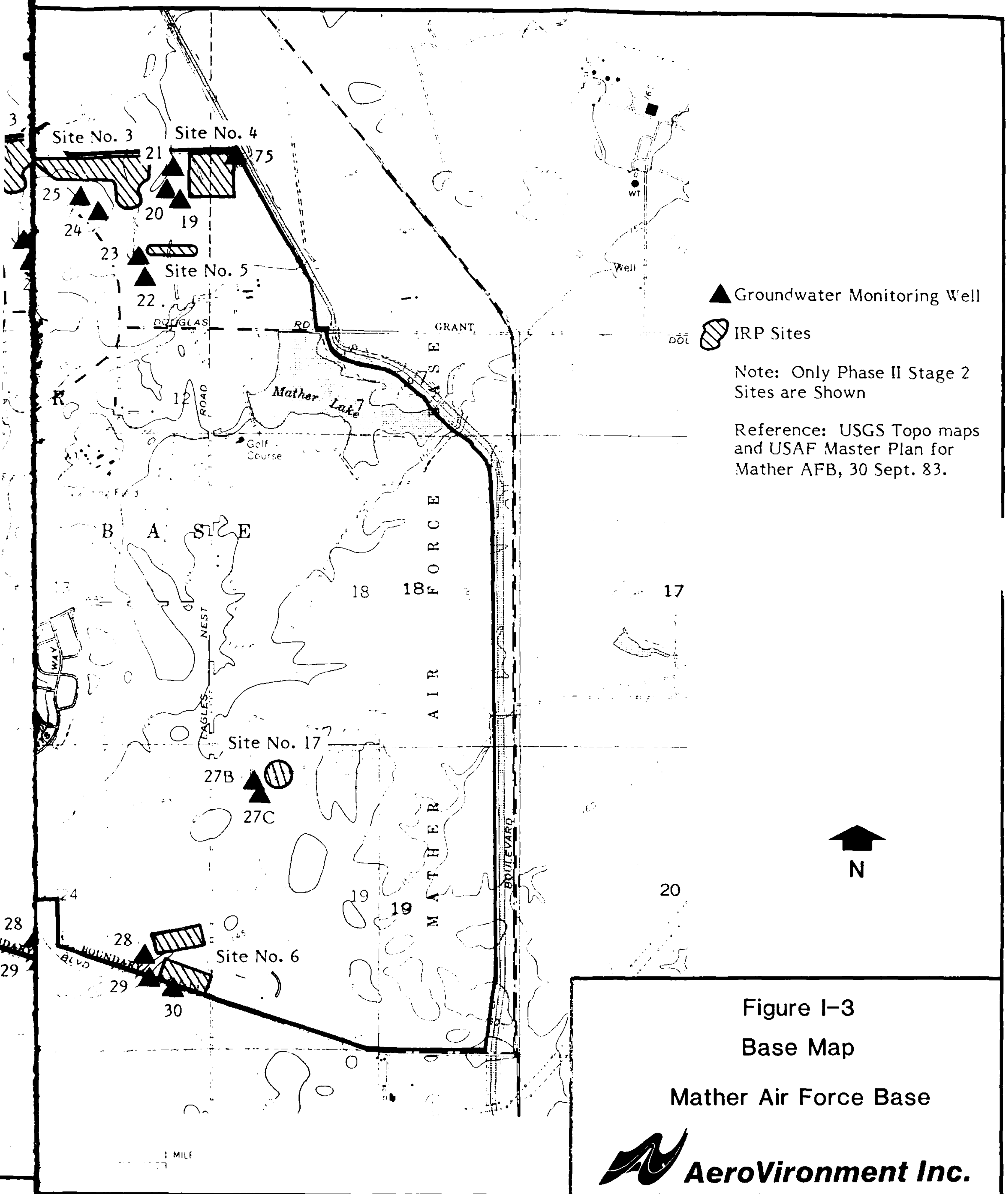

Figure I-3

Base Map

Mather Air Force Base

AeroVironment Inc.

June 1986

2. Drainage Ditch Site No. 2 (Site 14)

Drainage Ditch Site No. 2 is an unlined ditch located between Building 2950 and the motor pool area. Reports indicate that during the late 1960s waste oils and solvents were dumped directly into this ditch. How long this method of disposal was practiced is not known. In a past inventory, seven drums of TCE were on hand at the adjacent motor pool. Some spent TCE may have been dumped into the ditch.

3. Weapons Storage Septic Tank (Site 17)

A septic tank with associated leach field (Site 17) was used in the SAC weapons storage area until 1978, when it was connected to the sanitary sewer system. In this area, weapons are wiped down with small quantities of solvents. As a result, some of the waste solvents may have been disposed of in the septic tank. A past waste inventory showed that three drums of TCE were in the area.

4. Northeast Perimeter Landfill No. 2 (Site 4)

Located adjacent to and east of the NE Perimeter Landfill No. 1, the NE Perimeter Landfill No. 2 was the main sanitary landfill for the base from 1967 to 1971. During daily operation, waste was placed in long narrow trenches, burned and buried. A petroleum, oil and lubricants (POL) waste disposal pit is located at the NE corner of the site and was in operation during 1967 and 1968. It was reported that the POL wastes were transported in 500-gallon containers to be deposited in this landfill. Since TCE was in use during this period, some may have been included in the POL waste.

5. Existing Fire Protection Training Area (1958-1984)(Site 11)

The Fire Protection Training Area (FPTA) is situated south of the sewage treatment plant and adjacent to the "7100" Area Disposal site. This FPTA was used from 1958 to 1984 and consisted of a cleared area with an earthen berm. Until 1974, fire department training exercises were performed there daily, but

between 1974 and 1984 they were a quarterly occurrence. Approximately 100 to 500 gallons of POL wastes from flightline shops were used during each exercise.

In 1974, the practice of burning POL wastes was halted and two 1,000 gallon JP-4 storage tanks were installed above ground to be used on this site. From 1974 to 1979, JP-4 recovered from aircraft and containing no oils or solvents was used for training exercises. FPTA training consists of floating POL wastes on a bed of water, igniting the POL product and extinguishing the fire. Unburned hydrocarbons were left to seep into the ground with the water. From 1979 to 1984, JP-4 with less than 10 percent contamination has been used. Approximately 600 to 800 gallons were consumed during each exercise.

This type of fire training excercise has not been conducted at Mather AFB since 1984. During 1984, a concrete holding basin was constructed approximately 300 feet north of Site 11 for future fire training exercises. To date, this new fire training area has not been used.

6. FPTA No. 1 (Site 8)

FPTA No. 1 is located on the northwest corner of the runway, adjacent to Drainage Ditch No. 1 (Site 13). This original FPTA was in use during the years 1918 to 1922, 1930 to 1932 and 1941 to 1945. Weekly fire department training exercises were performed in what was once a cleared area with an earthen berm. Each exercise consumed 50 to 250 gallons of POL wastes that had been transported in drums and containers from the flightline. Although some solvents were known to be mixed with the POL wastes, TCE was not one of them, since it was not in use during this period.

7. FPTA No. 3 (Site 10)

A review of base air photos indicated that Site 10 had been incorrectly located during the Phase I survey. However, prior to the discovery of this error, geophysical surveys at the incorrect site identified a small anomaly. As a result, this site was called site 10A and investigated further for possible contamination. However, no information on the history of this area was available.

The actual FPTA No. 3 site lies beneath the current tanker-loading area. It was called Site 10B and was investigated according to the statement of work (SOW) From 1947 to 1958, when this site was in use, daily exercises consumed 100 to 500 gallons of POL wastes. Solvents mixed with these wastes did not include TCE, since it was not in use at the base during this period.

8. Northeast Perimeter Landfill No. 1 (Site 3)

The NE Perimeter Landfill No. 1, located 50 feet south of the northeast base boundary, was the main sanitary landfill for the base from 1959 to 1967. During daily operation, waste was placed in long narrow trenches, burned and buried. This procedure started on the western edge and, as each trench filled, progressively shifted toward the eastern edge.

During this period, each industrial shop was responsible for collecting and disposing of its own POL wastes. Base employees have indicated that drummed POL wastes were disposed of at this site. Mather AFB started using TCE in 1958, thus it may have been discarded there. Before 1966, however, most POL wastes were disposed of at FPTAs and Site 7. This indicates that only small amounts of POLs were likely to have been disposed of at this landfill.

Other materials which were reportedly disposed of at this site include hospital waste, waste paints and thinners, and empty pesticide containers.

9. Firing Range Landfill (Site 6)

From 1972 to 1974, the Firing Range Landfill was the main sanitary landfill for the base. In 1974, on-base sanitary landfill operations ceased. This site, located just inside the southern base boundary, was used primarily for garbage and household trash disposal. Reportedly, waste thinners and paint slops in drums were deposited here as well. Although POL wastes were not commonly disposed of at this site, some may have been sent here in drums.

10. "8150" Area Landfill Site (Site 2)

From 1942 to 1950, the "8150" Area Landfill Site served as the main sanitary landfill for the entire base. This landfill lies under a portion of the current SAC alert area and information concerning its operation is limited. However, it is common knowledge that during this time period POL wastes were disposed of in FPTAs and landfills. Therefore, POL wastes may have been discarded at this site.

11. MOGAS Spill Site (Site 20)

The MOGAS Spill Site is located next to the sewage treatment plant. In February 1982, the MOGAS fuel storage tank at this site was discovered to be leaking. It is estimated that the 150-gallon tank leaked approximately 700 gallons of fuel before being taken out of service.

12. Runway Overrun Landfill (Site 1)

Situated beneath the runway overrun of Runway 22 Right, the Runway Overrun Landfill was the base landfill prior to 1942 and all general refuse from the base was disposed of there. During this time, flightline industrial operations were small scale, so POL waste disposal was minimal.

13. Old Burial Site (Site 18)

Site 18, the Old Burial site, underlies the current parking lot adjacent to Building 4120. The records search indicated that this site was used for disposal of various stock items, tool boxes and some containerized ethyl mercaptan used in gas line testing. Records show that it also served as a general refuse landfill during the late 1940s.

14. Fuel Tank Sludge Burial Site (Site 19)

In the past, leaded AVGAS fuel tanks were used at Mather AFB. Sludge generated from cleaning these tanks was buried in the diked area at Site 19 and marked with a sign reading "Danger, Tetraethyl Lead Burial Site." In addition, the JP-4 fuel tanks are cleaned every three years and, until 1980, the small amount of sludge generated was weathered and disposed of at this site.

15. Northeast Perimeter Landfill No. 3 (Site 5)

During 1971, the NE Perimeter Landfill No. 3 was the main sanitary landfill for the base. It is located adjacent to and northeast of the base recreational vehicle storage area. Little POL waste was disposed of there and no wastes were burned, because that procedure was prohibited then.

D. Identification of Laboratory Parameters

The primary purpose of the investigation at Mather AFB was to determine the presence or absence of contamination in the uppermost aquifer. We also studied contamination in surface soils at two sites. The Phase I IRP report for Mather AFB indicated that organic chemicals were of concern at all of the 15 sites investigated. As a result, all water and soil samples were analyzed for volatile organics and for oil and grease. In addition, chloride, nitrate and sulfate ions were analyzed in samples from landfill sites to look for evidence of landfill leachate. Samples taken from sites related to fuel spills or fuel disposal (including FPTAs) were also analyzed for dibromochloropropane (DBCP), ethylenedibromide (EDB), and lead. Lead is a common contaminant when older leaded fuels are a concern. Soil samples were analyzed for the same parameters as water samples from that site. Table I-2 presents the site-specific analytical requirements.

E. Identification of Field Team

The field investigation team AV assembled for the Phase II, Stage 2 study at Mather AFB included AV personnel, a drilling subcontractor and a

TABLE I-2. Analytical requirements for soil and water sampling.

Site Number	Site Name	Analyses (method number)
13	Drainage No. 1	VOA (601/602)
14	Drainage No. 2	O&G (413.2)
17	Weapons Storage	VOA
3	Landfill No. 1	O&G
6	Firing Range LF	Cl^- (325.3)
2	8150 Landfill	NO_2^- (418B)
1	Runway Landfill	$SO_4^=$ (375.4)
5	Landfill No. 3	
4	Landfill No. 2*	VOA
11	Existing FPTA	O&G
8	FPTA No. 1**	DBCP (608)
10	FPTA No. 3**	EDB (509A/B)
20	MOGAS Spill	Lead (239.2)
18	Old Burial	
19	Fuel Tank Sludge**	

*Landfill No. 2 was not grouped with other landfills by USAF OEHL.
**Soil samples from these sites were analyzed for the same parameters as the water samples.

geophysical subcontractor. The AeroVironment team included the following professionals:

Douglas Taylor, P.E., is a project manager in AV's Environmental Programs Division. He has an M. Engr. in environmental engineering and six years' experience in hazardous waste management and site assessments. He has managed numerous DoD, EPA, and private party site investigations and sampling programs. Mr. Taylor served as project manager for the Mather AFB study. In this capacity, he was the main interface between AV and USAF OEHL. He was responsible for the scheduling of field work (drilling and sampling), for the management of drilling and laboratory subcontractors, and for personnel staffing and technical review.

Timothy O'Gara is the leader of AV's Earth Sciences Section. He holds a B.A. in earth science and has six years' experience in groundwater monitoring and hazardous waste investigations. Mr. O'Gara has directed drilling, groundwater monitoring well installation and soil sampling programs at sites throughout California. Mr. O'Gara was responsible for directing the well-drilling program at Mather AFB. His duties during this project included coordinating with base personnel, selecting well locations, supervising the drilling crews, and reporting on hydrology.

Christopher Lovdahl, an environmental chemist, holds a B.S. in environmental science and has six years' experience in environmental compliance, waste site sampling and analytical chemistry. He worked for four years at industrial facilities and analytical laboratories prior to his IRP involvement. Mr. Lovdahl was responsible for reviewing groundwater monitoring well sampling requirements and coordinating with the instrumental-analytical laboratories. He served as the point of contact between AV and the laboratory, instructing the laboratory on selected analytical methods and special sample handling. He also performed quality assurance/quality control (QA/QC) reviews on all laboratory data.

John Miller, a geochemist with an M.S. in geochemistry, has eight years' experience in geology and geochemistry in the mining and mineral processing

industries. He has worked extensively with soil sampling, laboratory analysis and quality assurance. Mr. Miller served as a field geologist during the well drilling program. He was responsible for logging the samples and designing the groundwater monitoring wells. He was also active in the QA/QC review of laboratory data.

Sheryl Thurston, an environmental engineer with a B.S. in environmental engineering, has one year's experience with IRP programs and state RCRA recordkeeping. Ms. Thurston served as a field engineer during well drilling at Mather AFB. She assisted with driller supervision and lithologic sample logging. She was also a part of the sampling team and conducted research on base operations and environmental setting.

Complete resumes of AV personnel mentioned above are included as Appendix I.

Beylik Drilling Inc. (Beylik) of La Habra, California, performed the drilling. Beylik has 40 years experience in drilling water production and monitoring wells at locations throughout California. The company and many of its personnel have specific experience drilling in the Sacramento area and working on IRP programs at other USAF bases. Beylik provided an Ingersoll Rand TH 100 air rotary drilling rig equipped with a casing hammer and support equipment. Beylik drilled, constructed and developed all 28 groundwater monitoring wells under the direction of AeroVironment field personnel.

Geophysical surveys were conducted on eight sites at Mather AFB by the Earth Technology Corporation (Earth Technology) of Long Beach, California. Earth Technology is a geotechnical consulting firm with over eight years' experience in geophysical investigations. The surveys were completed under the direction of Mr. Kerry Hennon (M.S. Physics, California Registered Geophysicist) of Earth Technology. Mr. Paul Hague performed the ground-penetrating radar (GPR) study. Mr. Hague's qualifications are a B.S. degree in Geophysics and eight years' GPR field experience. Mr. Timothy O'Gara of AV coordinated this activity.

Laboratory work was performed by Acurex Corporation (Acurex) of Mountain View, California. Acurex's Energy and Environmental Division joined with AeroVironment as part of the contract team for USAF OEHL. Mr. Greg Nichol (M.S., Chemistry, 8 years' laboratory management experience) served as program manager for the Acurex effort on this task.

II. ENVIRONMENTAL SETTING

A. Physical Geography

Mather AFB is located approximately 12 miles east of Sacramento, California, and one mile south of the American River, in the American Basin. The basin is a broad, shallow trough surrounded by natural levees and low alluvial plains and fans. It is a typically flat, poorly-drained land which has received flood waters when the natural levees have overflowed.

The American Basin, along with the Yolo Basin and the alluvial plains of the Sacramento River, helps to form the Sacramento Valley. This valley joins the San Joaquin River Valleys to constitute the Great Valley Physiographic Province that extends north to south from Red Bluff, California, to Bakersfield, California, and averages a width of 40 miles (USGS, 1979).

Tailings from a dredging operation to mine gold cover the area surrounding Mather AFB to the north, northwest and west. This gold mining operation dredged the upper 20 to 30 feet of sediment and redeposited the gravel and cobbles as mining tailings (CDMG, 1975). Thus, the surface soils in this area have a high permeability. No dredging was done at Mather AFB.

1. Topography

Mather AFB sits on a flat alluvial plain. Elevations range from 160 feet above mean sea level (msl) on the east side to approximately 60 feet above msl on the west side. The base has relatively low relief so that runoff rates are low. This affects infiltration rates in that rainwater is retained longer.

2. Soils

Soils at Mather AFB consist mostly of gravelly or sandy loam to a depth of about five feet. Most of the base is mantled by Corning gravelly loam, undulating Perkins gravelly loam, or Redding gravelly loam. These soil types have

a relatively low permeability with infiltration rates of 10^{-5} to 10^{-6} cm/sec. The only difference among these three types lies in their elevation and relief. The Corning soils have the highest elevation of the three. They consist of a red-brown gravelly loam which grades to a clay layer at about 3 feet below land surface (bls). Clay and gravel are prominent in the 3- to 5-foot layer. The Perkins soils consist of a brown or light brown gravelly loam which grades to a red-brown gravelly, heavy clay at approximately 3 feet bls. The Redding soils consist of a red-brown gravelly loam which grades to gravelly clay at about 3 feet bls. Upper soils are generally permeable down to the clayey layer which is fairly impermeable. This layer must be penetrated in order for any significant pathway for groundwater contamination to exist.

B. Regional Geology

Materials which underlie the Sacramento Valley and its adjacent mountains include Paleozoic and Mesozoic (400 and 70 million years old, respectively) igneous, metamorphic and marine sedimentary rocks. The "basement rocks" occur at shallow depths at the basin edge but at great depths in the center. This complex is overlain by a thick sequence of Eocene (34 million year old) marine and continental sedimentary rock which contains saline or brackish water. These rocks form the bottom of the basin and are impermeable; thus, no fresh water exists under them (USGS, 1977).

A series of continental deposits overlie the Eocene and pre-Eocene rocks. These post-Eocene sediments include volcanic rock that was formed in the mid to late tertiary period (CDMG, 1981). Formations of particular importance in the Mather AFB area include the Victor, South Forks Gravels, Arroyo Seco Gravels, Fair Oaks and Mehrten Formations, as well as alluvial deposits and buried stream channels.

The buried stream channels of the American River create superjacent deposits and are significant in affecting contaminant migration in a horizontal direction. These deposits are quite permeable (about 30 feet/day) and are oriented in a southwest to northeast direction, parallel to regional groundwater flow.

Significantly, one of these channels continues under Mather AFB in a southwest direction toward the off-base areas (Happy Lane) that have experienced problems with TCE contamination in domestic wells (CDWR, 1974). Additionally, directly up gradient of the base and over a buried stream channel is a large industrial complex, which could contribute to groundwater contamination (CVRWQCB, 1980).

At Mather AFB, the upper 600 feet of unconsolidated gravels, sands, silts and clays are significant to water supply and pollution migration. Below the soil layer the strata become more permeable. In areas where the clayey layer under the surface soil has been breached, infiltration into underlying strata may be very high. Alternating layers of sand, silt and clay of varying permeability separate the surface layers and the production zone for water supply wells. (See the lithological logs for base water supply wells in Appendix D.) This zone usually occurs at approximately 100 to 150 feet bls. The percolation rate to this zone is relatively higher in those areas where upper strata are predominantly sand and silt, rather than clay.

C. General Hydrogeology

In the Mather AFB area, groundwater occurs in the post-Eocene (<34 million years old) continental deposits beneath the Sacramento Valley. Most groundwater is stored and flows through sands or sands and gravels that were deposited in the past by streams (CDWR, 1978).

The most significant source of recharge in this region is infiltration through stream channels, particularly the American River. In those areas where the soil is sufficiently permeable, irrigation and rainfall can be an important source of recharge as well. At Mather AFB, soils contain low permeability layers which severely restrict downward movement of water. However, in certain areas (such as landfill trenches, sewer lines, drainage ditches) the low permeability layer has been breached and recharge is more likely through these pathways.

Under natural conditions (no pumping of water), groundwater in the Mather AFB area moved from a potentiometric high near Folsom, southwest toward the Sacramento River and turned south (CDWR, 1964). However, groundwater is discharged from the Mather AFB area primarily by pumping. These groundwater withdrawals have influenced local hydrogeology so that the Sacramento River is now a point of groundwater recharge rather than discharge, as it was previous to pumping. Also, the cone of depression caused by irrigation in the Elk Grove area (south and southwest of the base) influences groundwater flow at Mather AFB. While it probably does not affect the direction of regional flow, it can be directly linked to local variations in the flow path.

Before pumping began in the Mather AFB area, groundwater in the western portion stood at approximately 60 feet above msl (30 feet bls). As of Spring 1982, the level had receded to 10 feet above msl; a 50-foot decline in 70 years.

D. Historic Groundwater Problems

The only groundwater problems which are known to exist in the area of Mather AFB are those caused by releases of trichloroethene (TCE) into the uppermost aquifer from known and unknown sources in Rancho Cordova. The problems of TCE contamination resulting from Aerojet General Corp. are well documented and have been studied extensively by California officials (CVRWQ CB, 1980). TCE has been identified in off-base wells along Happy Lane (west of Mather AFB) but the concentrations have been somewhat erratic. The source of any TCE contamination at that location is not known. The final groundwater problem is TCE identified in groundwater sampled at the Air Command and Warning (AC&W) site at Mather AFB. This work was completed as part of a Phase II Stage 1 study. The source is not known, but additional work is scheduled at that site in 1986 as part of a Phase II Stage 3 survey.

Groundwater quality (at these three sites plus other nearby locations) will be discussed further in the following chapters of this report.

E. Location of Wells

Mather AFB has 15 pumping wells that make up six water supply systems (see Table II-1). The two golf course wells are used solely for irrigation, while the jet engine test cell well is used for fire protection and washwater for jet engine testing. The AC&W well was used for fire protection but is no longer used for any purpose. All other wells provide the base's general water supply. The locations of base wells are shown on Figure II-1.

In general, the main base wells produce water of good quality. Based upon extensive data collected by Mather Bioenvironmental Engineering (B.E.E.) personnel since 1983, TCE contamination has not been found in any of the active base production wells, except for trace quantities (below method detection limit). *Trihalomethanes (THMs), especially chloroform,* have been detected at low levels in several base production wells. THMs are common byproducts of drinking water disinfection. In March 1985, 1,2-Dichloroethane was detected above the DOHS action level in four wells -- MB-3, MB-4, Housing well No. 3, and the K-9 well. Since this was the only sampling event for the time period 1983-1986 in which this compound was detected, these results are suspect. Currently, base drinking water wells are sampled quarterly by the Mather B.E.E. for volatile halogenated organic compounds (EPA Method 601) to ensure contamination is detected if it occurs. Table II-2 shows this current data.

Numerous irrigation and domestic water supply wells are located within two miles of the installation boundaries. Information available on these wells is limited to the wells which have been tested by Mather AFB personnel for TCE. The location of these wells and base wells can be seen in Figure II-1. The results of sampling conducted by the Central Valley Regional Water Quality Control Board and Sacramento County Health Department are summarized in Table II-3.

F. Meteorology

The most significant meteorological parameter in assessing the potential for contaminant movement is rainfall. In the Sacramento area, most

TABLE II-1. Base Well Data[a].

Location	No. of Wells	Well Depth (ft)	Perforation Depth (ft)	Avg. Well Capacity (million gals/day)	Treatment
Main Base[b]	4	500-584	186-571	0.6-1.3	Chlorination
Family Housing[b]	6	400-584	205-500	0.6-1.7	Iron & Manganese Removal, Chlorination & Fluoridation
Golf Course[c]	2	390-403	No Data	1.0	None
ACW[d]	1	250	198-244	0.077	None
K-9 (SAC Ordnance)[b]	1	250	No Data	0.043	Chlorination
Jet Engine Test Cell[e]	1	200	39-79+	0.024	Chlorination

[a]Table obtained from Installation Restoration Program Records Search, p. IV-[illegible].
[b]Denotes drinking water well system
[c]Denotes irrigation well system
[d]Not used for any purpose
[e]Fire protection well/water wash

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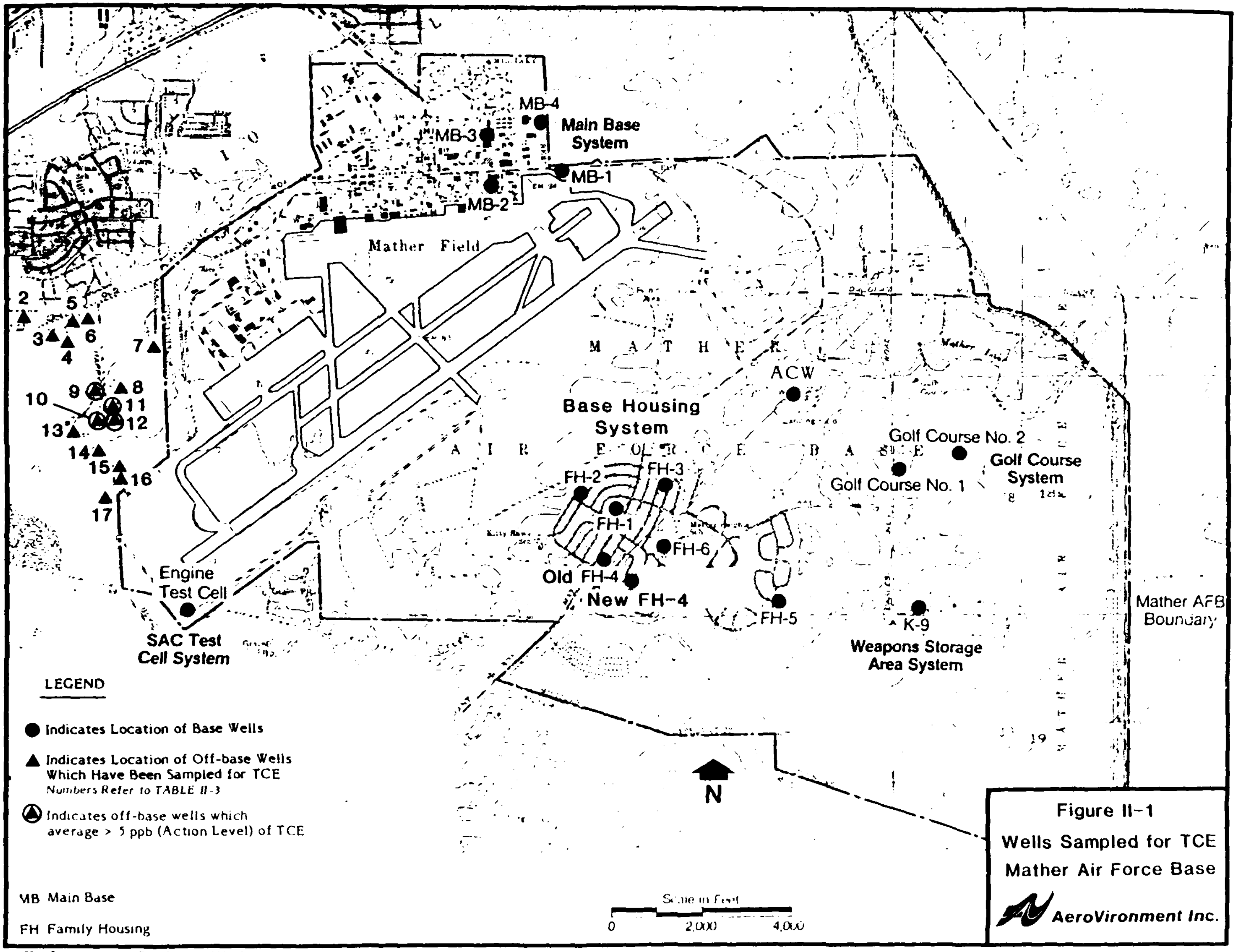


Figure II-1
Wells Sampled for TCE
Mather Air Force Base

Reference: CH2M Hill Phase I IRP Report, June 1982.

TABLE II-2. TCE Sampling Results at Mather AFB[a].

Well	Maximum Measurement of 21 Samplings (ppb)
Main Base No. 2	ND[b]
Main Base No. 3	ND
Main Base No. 4	ND
Housing No. 1	ND
Housing No. 2	ND
Housing No. 3	ND
Housing No. 4	ND
Housing No. 5	ND
Housing No. 6	ND
K-9 Well	ND

[a]All analyses performed by USAF OEHL, Brooks AFB, TX. Thirteen samplings cver a *three-year period* (6/83-9/86). Data obtained from Mather Bioenvironmental Engineering.

[b]ND = none detected.

TABLE II-3. TCE Sampling Results for Off-Base Wells[a]

	Well	Maximum Measurement (ppb)	Date of Maximum	Average of Measurements (ppb)	Other Compounds Found[b]
1.	Brugger	--	--	--	--
2.	Nobel	--	--	--	--
3.	Lisher	--	--	--	--
4.	FMC Properties	--	--	--	--
5.	Yokio, west well	1.4	3/82	0.2	PCE
6.	Yokio, east well	--	--	--	PCE
7.	Mather Camellia MHP	7.2	6/84	4.4	PCE
8.	Matsumoto House	1.1	4/84	0.5	--
9.	Rand	9.3	1/82	5.6	--
10.	Gregory	22	11/85	7.6	T-1, 2-DCE
11.	Hayashi	22	11/85	5.5	T-1,2-DCE; 1,1-DCE
12.	Furuike	15	6/84	6.5	T-1,2-DCE; 1,1-DCE; PCE; 1,1-DCA
13.	Church of the Gedatsu	1.8	3/82	0.6	T-1,2-DCE; 1,1-DCE; 1,1-DCA
14.	Tanaka	--	--	--	T-1,2-DCE
15.	Cordova Truck Dismanters	0.2	1/82	0.004	T-1,2-DCE
16.	Mather Truck Dismanters	--	--	--	--
17.	Kobata	--	--	--	--

a Data provided by Mather Bioenvironmental Engineering Shop. Samples collected and analyzed by State of California. All wells located along Happy Lane and Old Placerville Road, west of Mather AFB.

b Compounds found with equal frequency as TCE (or without TCE).

precipitation falls during the winter and spring months, with over half occurring during December, January and February. Table II-4 shows climatological data for the period 1971-1986.

Effective precipitation can be used as an indicator of the potential for leachate generation. The effective precipitation (mean annual precipitation 20.24 inches/year minus mean annual evapotranspiration 45 inches/year) in the Mather AFB area is -24.76 inches per year. This implies that precipitation has little change to percolate to the regional groundwater table, suggesting in turn a low potential for leachate generation via precipitation, especially considering the low permeability of soils on and near Mather AFB (EPA/530/SW-168). A monthly water balance calculation was performed, using data from nearby Nicholas, California. This calculation verified that there is no percolation during most years.

G. Site-Specific Geology

The site-specific geology at Mather AFB may be broken into five separate areas. As was mentioned earlier, the base is located on the eastern edge of a large alluvial basin. The geologic formations encountered during our drilling program were deposited by meandering or braided streams flowing from the Sierra Nevada mountains, and the groundwater is either perched, semi-confined, or water table. As shown schematically in Figure II-2, there are many buried stream channels, which may or may not be hydraulically interconnected.

The following section describes the geologic conditions in each of the five areas of the base. Figure II-3 shows the areas and the sites within them. The groundwater flow direction in all areas is to the southwest.

- Area 1

Area 1 lies at the northeast corner of the base and contains Sites 2, 3, 4, and 5 (see Figure II-3), all of which are landfills. Eleven groundwater monitoring wells were drilled by AV in this area. The soil in this area is listed by the United

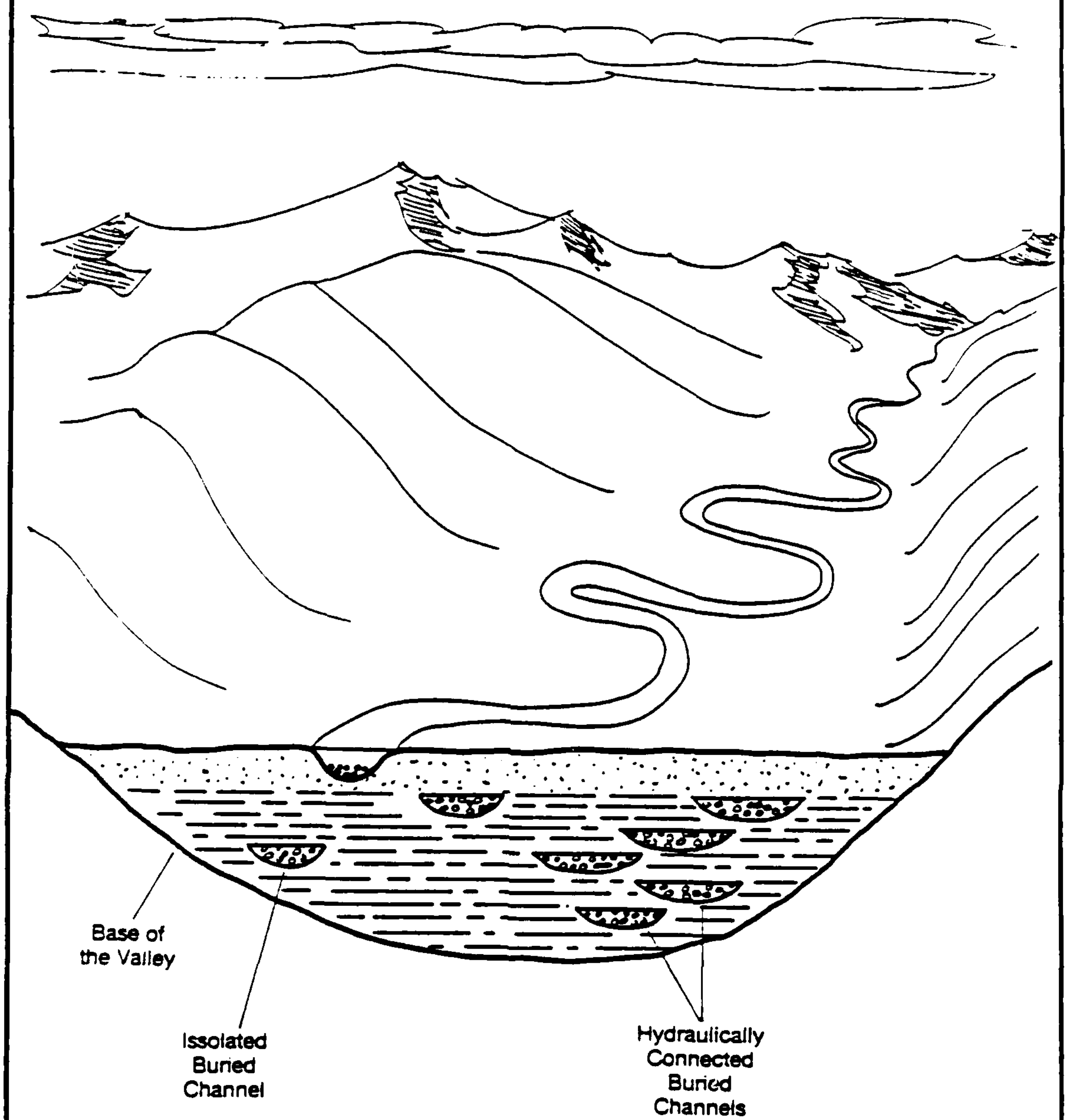
TABLE II-4. Climatological Data for Mather AFB.

PRECIPITATION (inches; 1971-1985)

	J	F	M	A	M	J	J	A	S	O	N	D	Yrly
Mean	2.84	2.94	3.33	1.53	0.24	0.10	0.16	0.16	0.47	1.34	3.54	2 92	20.24
Std. Dev.	3.15	2.06	2.28	1.27	0.39	0.12	0.37	0.32	0.48	1.01	2.60	1.88	9.13
Minimum	0.34	0.51	0.63	0.18	0.00	0.00	0.00	0.00	0.00	0.01	0.34	0.33	6.71
Maximum	9.53	6.16	8.84	4.64	1.38	0.26	1.35	1.01	1.69	3.02	6.70	6.48	40.23
24-Hr. Max (1941-1981)	2.6	3.0	1.90	4.30	1.10	0.80	1.40	1.00	1.90	4.40	2.60	2.20	4.40

TEMPERATURE (^{0}F; 1941-1981)

	J	F	M	A	M	J	J	A	S	O	N	D	Yrly
Mean Max.	53	59	64	70	78	86	93	91	87	77	63	54	73
Daily Min.	38	42	43	47	52	57	60	60	58	51	44	39	49
Mean Monthly	46	51	54	59	65	72	77	75	72	64	54	47	61
Extreme Max.	72	76	84	93	102	111	112	113	111	101	85	72	113
Extreme Min.	21	25	25	34	38	41	49	50	44	31	27	21	21



Reference: CH2M Hill, Phase I IRP Report, June, 1982.

Figure II-2

Buried Stream Channel Illustration

Mather Air Force Base

AeroVironment Inc.

June 1986

87-120

87-119

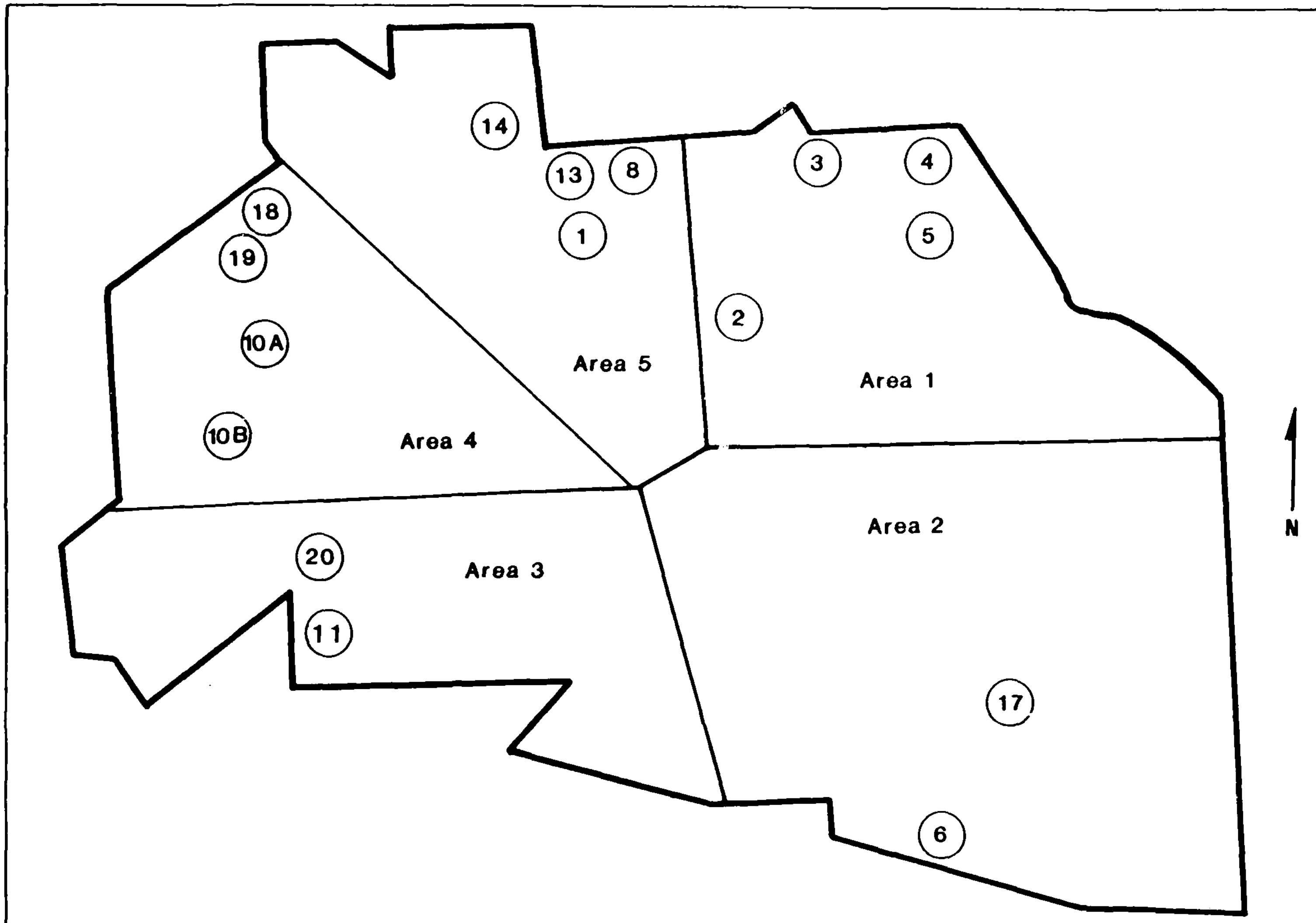


Figure II-3
Site-Specific Geology Sections
Mather Air Force Base

AeroVironment Inc.

June 1986

States Soil Conservation Service as Corning Gravelly Loam. It is generally no more than 3 to 5 feet thick and is developed on the South Fork Gravels deposited by the ancestral south fork of the American River. These gravels form irregular patches that are generally 20 to 50 feet thick and are currently being mined north of the base. In some localized areas, the gravels are absent. In Area 1, below the South Fork Gravels, the Laguna Formation is 30 to 35 feet thick, extending to a maximum of 75 feet below ground surface. In the field, this formation can be determined by a marked increase in the amount of silt and clay in the drill cuttings, and a total lack of clean gravels. This formation is not as clean (sand which is free of silt and clay) as the South Fork, and more silt and clay are present than would be found in the younger Victor Formation. Below the Laguna Formation, as is found elsewhere on the base, we encountered gravels that mark the Laguna-Mehrten transition zone. For clarity, we will consider these distinctive gravels to be the uppermost unit of the Mehrten Formation. The Mehrten Formation extends 120 feet bls, which marks the limit of our investigation in this area.

Groundwater is first encountered at 87 to 100 feet below ground surface and is occasionally semi-confined. The water table ranges from 20 to 40 feet above mean sea level (msl) with a southwesterly flow. (Further discussion of groundwater levels in all areas will be presented in Section IV.A.)

The exception to this groundwater pattern is Site 4, in the very northeast corner of the base. Wells drilled here have much more sand and less gravel than expected. MAFB-19 and 21 (MAFB-(number), is the designation given to groundwater monitoring wells by Mather AFB personnel) have 20- to 25-foot-thick units of silt and fine sand from 40 to 65 feet. The static water level in these wells conforms to our semi-regional projection by being about 40 feet above msl. MAFB-20, located between MAFB-19 and 21 was apparently drilled into an abandoned stream channel that is not hydraulically connected to the regional water table. The silt section is missing in MAFB-20 and the static water level is 70 feet above msl, 30 feet higher than in MAFB-19 or 21, which are 200 feet away. All three wells are drilled to the same depth. The gravel section in MAFB-20 may be hydraulically connected to the quarry located just to the north. During our study,

the quarry contained standing water at approximately the same depth as the static water level in MAFB-20.

o Area 2

Area 2 is located in the southeast corner of the base and includes Site 17, a septic tank, and Site 6, a landfill (see Figure II-3). AV drilled four groundwater monitoring wells in this area. These sites are covered with a shallow (<3 feet) soil that is described by the Soil Conservation Service as Redding Gravelly Loam. Below the soil mantle lies the Arroyo Seco Gravels. These gravels are interbedded with very thin (0.5 to 1.0 feet) layers of sandy clay and occasional medium to coarse sand zones. The Arroyo Seco Gravels are thinner than the South Fork Gravels and extend to a maximum of only 28 feet below the ground surface in our borings.

Immediately below the gravels, we encountered the Laguna Formation. It appears to be from 65- to 90-feet thick in this area of the base. The predominant lithology of the Laguna Formation is silty clay and sand with occasional silty gravel seams. We found the Laguna to extend to depths of 100 to 115 feet bls in our borings.

Below the Laguna, the lithology becomes gravelly and sandy once again, and silt is noticeably absent. This marks the upper limit of the Laguna-Mehrten transition zone. It appears to underlie the Laguna formation in most of the wells drilled on base. The gravel and sand are present down to the bottom of the borings (a maximum of 145 feet below ground surface), so the total thickness of this layer is not known. It is at least from 25 to 40 feet thick in this portion of the base and thickens to the west. The Mehrten formation has been mapped as being up to 450 feet thick at other points in the Sacramento area.

Groundwater was first found in the gravels of the Mehrten formation at a depth of 120 to 135 feet. This is a water table aquifer, as the incomplete saturation of the gravel indicated. However, direct recharge by percolation from the surface at this point is not likely, due to the silty, clayey nature of the overlying Laguna formation.

o Area 3

Area 3, in the southwest corner of the base, contains Site 20, a MOGAS spill, and Site 11, a fire protection training area. One groundwater monitoring well was installed at each site during the Phase II, Stage 2 study. Three wells were previously installed in the same area during Phase II, Stage 1 (MAFB-7, 8 and 9). Below the thin (1 to 2 foot) soil layer of San Joaquin Loam, and extending to a depth of 28 feet, all the wells encountered very large, well-rounded cobbles with little sand and no clay. This is the Arroyo Seco Gravel. At 28 feet, the lithology changes in two of the wells from the earlier study (MAFB-7 and 8) to the silty sands and clays of the Laguna Formation. The third well from the earlier study, MAFB-9, and the two drilled for this study (MAFB-38 and 39) have the gravel down to 50 to 55 feet before the Laguna is encountered. In MAFB-38, 39, and 9, the Laguna Formation stretches from 55 feet down to the total depth of 140 feet. The formation is silty and clayey sands and gravels, but is slightly coarser overall than at the east edge of the base.

MAFB-7 and 8 are entirely different from 28 feet to their total depth of 128 feet. The Laguna extends from 28 feet down 80 or 90 feet. Below the Laguna, there is a section of what is described in the earlier report as "black gravel." This could be the uppermost unit of the Mehrten Formation that was found below the Laguna in most of the wells drilled for this study.

Groundwater levels in this area fall into two groups, as would be expected from the lithology in the test wells. MAFB-7 and 8 have static water level readings 10 to 15 feet lower than MAFB-38, 39, and 9. The water table in MAFB-7 and 8 is confined or semi-confined, as shown by the water rising up the well, above the top of the gravel zone, to 20 feet into the silt and clay overlying the gravel. The water level readings in MAFB-7 and 8 are close to what is expected from regional trends.

MAFB-38, 39, and 9 have water level readings that are higher than would be expected by looking at regional trends alone. The water in these wells appears to be in an interbedded sand and clay zone. It seems also to be under a

slight amount of head, as it rose up in the well casing after it was first encountered during the drilling process. There is an abandoned gravel quarry directly west of the base at this point. It is possible that the high groundwater found in the three wells results from them being recharged from this area of high infiltration. Or this area may be being recharged from the surface due to the extremely coarse material found here, and the water is not reaching MAFB-7 and 8 due to the thick silt and clay cap over the water-bearing zone.

- Area 4

Area 4 is in the extreme west end of the base. It has essentially a layer cake lithology composed of the Victor Formation, the South Fork Gravels, and the Laguna Formation gradually dipping toward the center of the Sacramento Valley. This area contains Sites 10-A, 10-B, 18, and 19. There are 7 monitoring wells in this area, 5 from this stage and 2 from the Stage 1 survey. All of the wells encounter a sandy section of Victor Formation, between 8 and 20 feet thick, just below the loamy surface soil. Directly below the Victor Formation, in all the wells, there is a thick (20 to 40 feet) section of the South Fork Gravels. Below the South Fork, at a depth of between 40 and 55 feet below the ground surface, is the Laguna Formation. None of the borings in this area penetrate the Laguna and encounter the Mehrten Formation. The wells, which range from 82 to 120 feet deep, verify that the Laguna Formation is at least 60 feet thick at this point.

We encountered groundwater, apparently under water table conditions, in the silty sands of the Laguna Formation in this area. The static water level in all the wells conforms to expected regional water levels (60-70 feet bls), and flow is generally to the southwest.

- Area 5

Six wells were drilled to investigate Sites 1, 8, 13, and 14. The same general "layer cake" arrangement of formations as in Area 4 was found here. Throughout Mather AFB, this layer cake inclines gradually toward the southwest. As Area 5 is northeast of Area 4, the formation is closer to the surface here. The

Victor Formation is found in all of the wells with the exception of MAFB-12 (Site 8). It is very thin in this area, never more than 8-feet thick, and it pinches out between Sites 13 and 8.

Below the Victor Formation (from the surface at Site 8), the South Fork Gravels extend down to a maximum depth of 35 feet below ground surface. This formation is not as thick here as it is at other parts of the base. The Laguna Formation underlies the South Fork Gravels in all the wells drilled for this study. It is 35 to 55 feet thick and very fine grained at this point. The predominant lithology is silt or silty clay with a total absence of gravel or coarse sand.

Under the Laguna Formation, at a depth of 60 to 90 feet below the ground surface, lies the Mehrten Formation, which consists of clean sand and gravel with little or no silt or clay. The Mehrten Formation dips toward the southwest, as do the other formations found under the base and, by the time it reaches the western edge of this area, it is below the area of investigation (approximately 110 feet).

Groundwater is found in the gravels of the Mehrten Formation 70-75 feet below ground surface, and it is at least semi-confined by the Laguna Formation. As is the case in other parts of the base, there are occasional areas of perched water at the contact of the South Fork Gravels and the Laguna Formation.

H. Site Descriptions

The locations of the sites at Mather AFB are shown in Figure I-3. This section provides physical descriptions of each of the 15 sites in the Phase II, Stage 2 SOW, including size, location, type of operation and suspected contaminants.

1. Site 13 -- Drainage Ditch Site No. 1.

Site 13 is located across the street from the main base water storage reservoir and adjacent to a former aircraft washrack operation. From 1960

to 1973, aircraft operations included paint stripping and degreasing B-52 and T-29 aircraft; the latter required the use of TCE. Waste oils and solvents poured into an oil skimmer overflowed into an unlined open drainage ditch that leads into a culvert under the runway. Before the oil skimmer was installed in the summer of 1968, these wastes may have been poured directly into the ditch. This drainage ditch, which is located 400 feet southeast of Base Well MB-1 and 400 feet from the base boundary, was suspected to be a source of TCE detected in Base Wells MB-2, 3 and 4 during the 1979-1980 time frame.

2. Site 14 -- Drainage Ditch Site No. 2.

Site 14 is 600 feet southwest of Base Well 4 and 500 feet from the base boundary. During the late 1960s, reports indicate that waste oils and solvents were dumped directly into Site 14, an unlined ditch located between building 2950 and the motor pool area. How long this method of disposal was practiced is unknown.

In a past inventory, seven drums of TCE were on hand at the motor pool. Some of this may have been dumped into the ditch. Thus, this site is also suspected to be a source of the low-level TCE that was detected periodically in Base Wells MB-2, 3 and 4 during 1979-1980.

3. Site 17 -- Weapons Storage Septic Tank.

Site 17 is located at the SAC weapons storage area. A septic tank was in use here until 1978, when this area was connected to the sanitary sewer system. Small quantities of solvents were used to wipedown weapons parts in the area. Some of the waste solvents may have been disposed of in this septic tank. Additionally, a past waste inventory showed that three drums of TCE were in the area, indicating that some may have been disposed of in the septic tank. This system is suspected to be a source of TCE contamination that has been detected at the nearby Base Well K-9 during the 1979-1980 time frame, which is 800 feet northwest of the site. The base housing area is 2400 feet northwest and the base boundary is 3800 feet from the site.

4. Site 4 -- Northeast Perimeter Landfill No. 2.

From 1967 to 1971, Site 4 was the main sanitary landfill for the entire base. It is located 50 feet from the base boundary. When in operation, waste was placed in long, narrow trenches, burned and buried. A POL (petroleum, oil and lubricants) waste disposal pit approximately 40-feet long x 40-feet wide x 10-feet deep is located at the NE corner of Site 4 and was in operation for two years from 1967 to 1968. The POL wastes were reported to have been transported in 500-gallon containers to be deposited in this landfill. Since TCE was in use on the base during this period, some may have been included in the POL waste.

The Sacramento Army Depot is also reported to have used this site to deposit trash.

5. Site 11 -- Existing FPTA (1958-1984).

Site 11 is located south of the sewage treatment plant and just south of the current fire training area. The jet engine test cell Base Well is 3,000 feet west of this site, the base boundary is 300 feet away, and Morrison Creek is 600 feet away. Site 11 consisted of a cleared area and an earthen berm. Until 1974, training exercises were performed there daily, but between 1974 and 1984 they were a quarterly occurrence. Approximately 100 to 500 gallons of POL wastes from flight line shops were used during each exercise.

In 1974, the practice of burning POL wastes was halted. From 1974 to 1979, only clean JP-4 (recovered from aircraft) was used for training exercises. This type of JP-4 does not contain any oils or solvents. From 1980 to 1984, JP-4 with less than 10% contamination has been used. Approximately 600 to 800 gallons are consumed during each exercise.

6. Site 8 -- Fire Protection Training Area No. 1 (FPTA 1).

Site 8, which is believed to be located 500 yds east by southeast of the main base water storage reservoir 1,300 feet southeast of Main Base Well MB-1, 500 feet from the base boundary, was the original FPTA on base. Until 1945, this cleared area, which is surrounded by an earthen berm, was used for weekly fire department training exercises. Each exercise consumed 50 to 250 gallons of POL wastes that had been transported in drums and containers from the flight line. Although some solvents were known to be mixed with the POL wastes, TCE was not in use during this period and was not one of these solvents.

7. Site 10 -- FPTA No. 3.

A review of air photos of the base showed Site 10 had been incorrectly mapped. The actual FPTA was located under the current tanker-loading area. This FPTA site will be referred to as 10B and the original site will be referred to as 10A. Both sites are approximately 2200 feet from an off-base residential area. Site 10B was in use from 1947 to 1958. Daily training exercises there consumed 100 to 500 gallons of POL wastes per exercise. Solvents mixed with these wastes did not include TCE.

8. Site 3 -- Northeast Perimeter Landfill No. 1.

From 1950 to 1967, Site 3, which is 50 feet south of the northeast base boundary, was the main sanitary landfill for the base. As at Site 4, during daily operation, waste was placed in long narrow trenches (approximately 300-feet long, 20 feet wide, 18 feet deep), burned and buried. This procedure started on the western edge and, as trenches filled, shifted to the eastern edge.

During this period, each industrial shop was responsible for collecting and disposing of its own POL wastes. Base employees have indicated that drummed POL wastes were disposed at this site. As Mather AFB started using TCE in 1958, when this landfill was in operation, some TCE may have been discarded at this site. Before 1966, however, most POL wastes were disposed of at

the FPTAs and Site 7. Thus only small amounts of POL wastes are likely to be found at this landfill.

Other materials which were reportedly disposed at this site include hospital wastes, waste paints and thinners, and empty pesticide containers. Reports also indicate that the Sacramento Army Depot disposed of trash here.

9. Site 6 -- Firing Range Landfill.

From 1972 to 1974, Site 6, located 10 feet north of the southern boundary of the base, was the main sanitary landfill for the base. It was made up of a drainage swale and two trenches approximately 40-feet wide, 150-feet long and 18-feet deep. It also contains one trench north of the drainage swale that is approximately 40-feet wide, 200 to 300-feet long and 18-feet deep. These trenches are now easily distinguishable, because their cover extends 7-12 feet above ground level. This site was used primarily for garbage and household trash disposal. Reportedly, waste thinners and paint slops in drums were deposited there as well. Although it was not common practice to dispose of POL wastes at this site, some may have been sent here in drums.

10. Site 2 -- "8150" Area Landfill Site.

From 1942 to 1950, Site 2 became the main sanitary landfill for the entire base. A section of the current SAC alert area was constructed over this landfill site, which is located 2,480 feet northwest of the AC & W Well and 3,400 feet north of base housing. Information on the operation of this landfill is limited; however, it is common knowledge that during this period POL wastes were disposed in the FPTAs and landfills. Therefore, POL wastes may have been discarded at this site.

11. Site 20 -- MOGAS Spill Site.

Site 20 consists of a 150-gallon underground leaded MOGAS fuel storage tank which supplied fuel for an emergency power generator. It was located

at the sewage treatment plant, 800 feet from a base boundary. In February, 1982, this tank was discovered to be leaking. The entire fuel supply leaked from the tank over a two-week period. Base officials estimated the tank leaked approximately 700 gallons of fuel before it was removed.

12. Site 1 -- Runway Overrun Landfill.

Site 1, situated at the runway overrun, 960 feet southeast of Base Well MB-1 and 900 feet from a base boundary, was the original base landfill. During its operation, which ended in 1942, it was used for disposal of all general refuse from the base. Prior to 1942, flightline industrial operations were small scale, so we assume that the amount of POL wastes disposed of here were minimal.

13. Site 18 -- Old Burial Site.

Site 18 is located in the current parking lot adjacent to Building 4120, 650 feet from the base boundary and an off-base residential area. Trash and debris were encountered during installation of the parking lot. During a records search, interviewees indicated that this area was used to dispose of items such items as tool boxes, stock items and containerized ethyl mercaptan, which had been used in gas line testing. Records also show that during the late 1940s, the site was used as a general refuse landfill.

14. Site 19 -- Fuel Tank Sludge Burial Site.

Site 19, located inside a diked area containing two above-ground JP-4 storage tanks and 1,400 feet from off-base wells and 400 feet from an off-base residential area, is marked with signs reading "Danger, Tetraethyl Lead Burial Site." The waste disposed of here was sludge from past fuel tank cleaning operations. The leaded AVGAS tanks were cleaned approximately every three years and the quantity of sludge produced was small. During disposal operations, sludge was weathered and buried inside a diked area. According to facility personnel interviewed as part of the Phase I record search, the pits for burying the sludge were dug by hand and were very shallow. Leaded AVGAS is no longer stored

at Mather AFB. Currently, sludge generated from other tanks is managed as hazardous waste.

15. Site 5 -- Northeast Perimeter Landfill No. 3.

During 1971, Site 5 was the main sanitary landfill for the base. It consists of a single trench approximately 300-feet long, 25-feet wide and 18-feet deep. The operation of this landfill did not include burning because that procedure was prohibited in 1971. Very little POL waste was disposed at this site, because most of these wastes went to the FPTAs and to central collection for recycling during this period. Reportedly, Sacramento Army Depot also used this site for trash disposal.

I. Summary of Environmental Setting

A review of the environmental setting at Mather AFB reveals the following pertinent information:

- Soils are characterized by low permeability and a local effective precipitation of -24.76 inches per year, both of which create a low driving force for contaminant migration. However, a pathway for groundwater contamination may be created if the impermeable hardpan layer below the surface soil is penetrated. The base's low topographical relief may further increase a normally low infiltration rate, as well.

- Surface soils surrounding Mather AFB to the north, northwest and west are highly permeable because of past gold mining operations. A large industrial complex upgradient of Mather AFB, which sits atop this highly permeable soil, may be a source of migrating contaminants.

- Buried stream channels of the American River, which are the most significant source of groundwater recharge in this region, are known to create overlying deposits and enhance horizontal contaminant migration. Additionally, directly upgradient of the base and over a buried

stream channel is the previously mentioned industrial complex. This could contribute to contaminant migration on-base as well.

- The geology on-base generally consists of surface soils of low permeability, below which lies the Victor Formation. This is made up of interbedded sands and clays, which inhibit contaminant migration from the surface. Below this Formation sits a highly permeable sand and/or gravel zone that may be the Arroyo Seco or South Fork Gravels, depending on the site-specific geology. Under these gravels, lies a zone similar to the Victor Formation called the Laguna Formation. Finally, the lower zone, which contains the water table aquifer, is the Laguna-Mehrten transition zone.

- The 15 pumping wells at Mather AFB are used for irrigation, fire protection, washwater or general water supply on-base. In general, the main base wells produce water of good quality. Extensive sampling conducted on the base production wells during 1983, 1984, 1985 and 1986 has shown no evidence of contamination except for TCE in the ACW well and the Jet Engine Test Stand well. Some off-base wells within two miles of the base have also been found to contain traces of TCE.

III. FIELD PROGRAM

A. Development

1. Preliminary Activities

AeroVironment began its involvement at Mather AFB in May 1985. USAFOEHL requested that AV personnel visit Mather AFB and discuss the proposed Phase II, Stage 2 activity with Capt. James Curran, the Base Bioenvironmental Engineer (BEE). This meeting took place on May 7, 1985. Each of the proposed sites was visited and AV was briefed on previous IRP work conducted at Mather AFB and the history of each site.

After visiting the base, AV worked with USAFOEHL to finalize the Statement of Work (SOW) for the project. The only major changes to the SOW originally submitted by Weston were that mud rotary drilling was replaced by air rotary drilling, and downhole geophysical logging of the holes was eliminated. These changes were the result of comments received from regulatory agencies working with USAFOEHL. The final statement of work for this task order is included in Appendix B.

2. Subcontractor Selection

a. Drilling. The statement of work called for drilling 29* groundwater monitoring wells using air rotary methods with a casing hammer. Up to 4 shallow soil borings using hollow stem augers and 3 shallow hand augerings were also authorized. During the period between the finalization of the SOW, and the assignment of the task order, AeroVironment contacted potential drilling subcontractors about availability of air rotary drilling equipment. Because this is a relatively specialized drilling method, only three qualified drilling companies were found.

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*The 29th well was constructed with money from this task but was part of the Phase II Stage 3 technical effort.

AeroVironment prepared a Request for Bid (RFB) package for the well drilling and hollow stem augering work. It asked for cost quotations of hourly rates for drilling, well construction and development. The bidders also quoted material costs for well construction.

On August 2, 1985, the RFB package was sent to the following nine drilling companies:

Allen Drilling and Equipment, Grass Valley, CA
Beylik Drilling, La Habra, CA
Bryant Kennedy Drilling Auburn, CA
Continental Drilling U.S., Newport Beach, CA
E.E. Luhdorff Co., Woodland, CA
J.C. Plummer and Company, Chico, CA
John Field Drilling, Auburn, CA
P.C. Exploration, Roseville, CA
Water Development Corporation, Woodland, CA

Bids were received from Beylik, P.C. Exploration and Water Development by the deadline of August 19, 1985. The bids were evaluated for cost and demonstration of ability to perform the work. All three firms were judged to have adequate experience in projects of similar size and scope. Beylik was selected based on their lower bid prices for this project. They also have experience working on IRP projects at several bases in California and Arizona.

Hollow stem auger drilling was originally scheduled for one site (No. 10). A geophysical survey showed two small anomolies at the reported location of that site, but a subsequent review of air photos showed that the site was located under the flight apron. All soil borings were eliminated because of these findings; however, near the end of the program two borings were readded to investigate the anomolies at the originally reported site. Water Development Corporation was selected to drill these two borings because of their proximity to the site (and the resulting minimal mobilization charge for the auger rig).

b. Geophysical Studies. The statement of work called for AeroVironment to conduct geophysical studies (ground-penetrating radar and resistivity) on eight of the sites at Mather AFB. Between May and September, AeroVironment asked two firms to submit technical and cost proposals to complete this work. The Earth Technology Corporation (Earth Technology) of Long Beach, California, and Converse Consultants of Pasadena, California, submitted proposals that were considered technically equivalent. Earth Technology was selected to perform the work based on slightly lower estimated price. Earth Technology's proposal included using Mr. Paul Hague as a speciality consultant for the ground-penetrating radar segment.

3. Sample Plan Development

The project SOW did not require that a formalized sample plan, such as a technical operations plan, be developed. However, AV developed a field activities plan that described how the various sampling activities would be completed. Much of it was prepared by Weston, during the presurvey reporting. After receiving project authorization, specific details were included in the work plan developed for this effort. (Refer to Section III. B.2 and III.B.3 for a discussion of the sampling methods.)

After the drilling method was changed from mud rotary to air rotary, AeroVironment rewrote the specifications. We included the details of the drilling method in the subcontract document with Beylik Drilling Inc.

4. Safety Plan

AeroVironment and USAF policy require that an appropriate health and safety plan be prepared before field activities can begin. Safety concerns related to this field work focused on the hazardous nature of some chemicals suspected of being present at the site, as well as the "unknowns" relative to exact location, concentration and volume of possible contaminants. In addition, digging in contaminated areas increases the potential for airborne release of chemicals. Also, drilling machinery has the potential for mechanical injury.

The site safety plan used by AV's field team is included in Appendix K. It required that all field personnel wear standard work outfits (steel-toed boots, hardhats, etc.). It also required that the air above the drilling borehole at all sites be monitored for organic vapors, oxygen deficiency and explosive gases.

Work at all the sites at Mather AFB consisted of drilling, well development and sample collecting. These activities bring previously isolated and potentially contaminated soils and water to the surface. The potential for skin exposure or inhalation is significant. The drilling program was specifically designed to eliminate drilling through waste material or spill sites. AV placed all wells at up-gradient or down-gradient locations. All work areas were in relatively flat areas, out of doors, with good air circulation. When handling apparently uncontaminated samples, workers wore new, disposable latex gloves at each sampling location to keep skin clean and to avoid cross-contamination from sample handling. When collecting samples thought to be contaminated, workers wore coveralls and 14-inch neoprene gloves over the latex gloves.

The ambient air was monitored and recorded to alert the field team, should breathing zone concentrations rise above acceptable levels. At Mather AFB, the following action levels were set up for organic vapor meter readings:

0-5 ppm (above background): no respiratory protection needed
5-50 ppm: air purifying respirator with
organic chemical cartridge
50 - 500 ppm: self-contained breathing apparatus
500 ppm and above: no work allowed

Other criteria were set for oxygen deficiency and explosive gases. No readings above background concentrations were measured during any of the work conducted at Mather AFB.

USAF personnel at Mather AFB were aware of all activities performed each day. Emergency services (fire, police and hospital) were available on-base.

B. Implementation of Field Program

1. Drilling and Well Installation

All wells were drilled by standard air rotary methods, using an Ingersol Rand TH100 drilling rig. A schedule of drilling and well construction activities is presented in Table III-1. Initially, there were fears that unconsolidated sediments in the shallow subsurface would potentially cave during the drilling process. To avoid this, the rig was equipped with a casing hammer, and drive casing was used to keep the hole open during drilling.

During the early stages of the drilling program, drive casing was driven to the total depth of the boring. After well installation, the drive casing was withdrawn, exposing the well to the formation. Gravel pack, bentonite, and grout were installed while the drive casing was being removed. As the program progressed, it was found that the formations below 40-60 ft were consolidated enough to stay open without drive casing. By only driving outer casing to 60 feet, and drilling open-hole until water was encountered, we were able to further streamline the operation.

Two drilling rigs were used for this portion of the project. The rig previously described drilled the hole, drove the outer casing, and installed the well casing and gravel pack. A second rig, equipped with large hydraulic jacks, jacked the drive casing out of the ground, for later use, and grouted the hole to the surface.

a. Well Installation

A total of 29* wells were installed to monitor the uppermost saturated zone at Mather AFB during this phase. The locations of these

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* The 29th well was constructed with money from this task, but was part of the Phase II Stage 3 technical effort, and was sampled and reported under Stage 3. No further discussion of this well will occur in this report.

TABLE III-1. Well Drilling, Construction, and Development Timetable.

	Well No.		
Date	Drilled	Constructed	Developed
10/1/85	13		
10/2/85	13		
10/3/85	15a		
10/5/85	28		
10/7/85	15b		
10/8/85	15b 14	13	
10/9/85	12	12 28, 15, 14	13
10/10/85	22 23	 28	14, 15
10/11/85	23 24	22 23	12
10/12/85	26		
10/14/85	21 20	24 26 (started)	
10/15/85	20	21	22
10/16/85	19	19 20	
10/17/85	25 29		19 20
10/18/85	29 30	25 26 (completed) 29	23 24
10/19/85			26
10/21/85	39		25 21
10/22/85	39	30	28, 29
10/23/85	38		30
10/24/85	38 27	38 39	

TABLE III-1. (con't)

Date	Well No. Drilled	Constructed	Developed
10/25/85	27		38 39
10/26/85	27A		
10/28/85	18		
10/29/85		18	
10/30/85	27B 17		18
10/31/85	17	27B 17	
11/1/85	33 34	33	17 27B
11/2/85			33
11/4/85	35 36	34 35	34
11/5/85	37 31	36 37	35
11/6/85	31 32	31 32	36 37
11/7/85	27C		31 32
11/8/85	16	27C	
11/11/85		16	16
11/12/85			27C

Note: Wells 15A, 27 and 27A were grouted to the surface and replaced.

wells are shown in Figure I-3. Of these wells, 10 were constructed using stainless steel well screens with mild steel riser pipe. Low carbon stainless steel wells were installed at sites that the USAF had identified as sites that might require long-term monitoring (Sites 4, 11, 10, 18 and 19). The remaining wells were constructed of PVC. Figure III-1 diagrams a typical monitoring well and Appendix D contains diagrams of all wells installed for this project along with the lithologic logs of the borings.

Using information on groundwater flow and gradients from an earlier IRP study, AV selected the well locations so that they would be down gradient from the sites to be investigated. At the eight sites that had been investigated in the geophysical phase, the results were used to further "fine tune" the drilling locations to intercept any contamination plumes from the sites.

We drilled bore holes down to about 20 feet below the water table. (Using the air rotary, we could easily identify when we encountered saturated material.) Well screens were placed 10-15 feet into the saturated zone, to allow for fluctuation in the water table. Thus, we were able to monitor the surface of the water table and the capillary fringe for hydrocarbons or other light contaminants.

b. Well Development

The drillers developed the wells shortly after they were drilled, using standard water well techniques. All wells were first swabbed and bailed using a close fitting dart-bottom suction bailer to remove any sediment build-up that would fill the perforated zone of the well casing. Next, they pumped until the water was flowing clean and clear. Finally, they bailed out all sediment that had accumulated during pumping and capped the well. By using this method, the average well was developed in slightly less than five hours.

c. Surface Completion

The nine wells sited within the industrial area of the base or near the flightline were completed flush with the ground surface and placed in

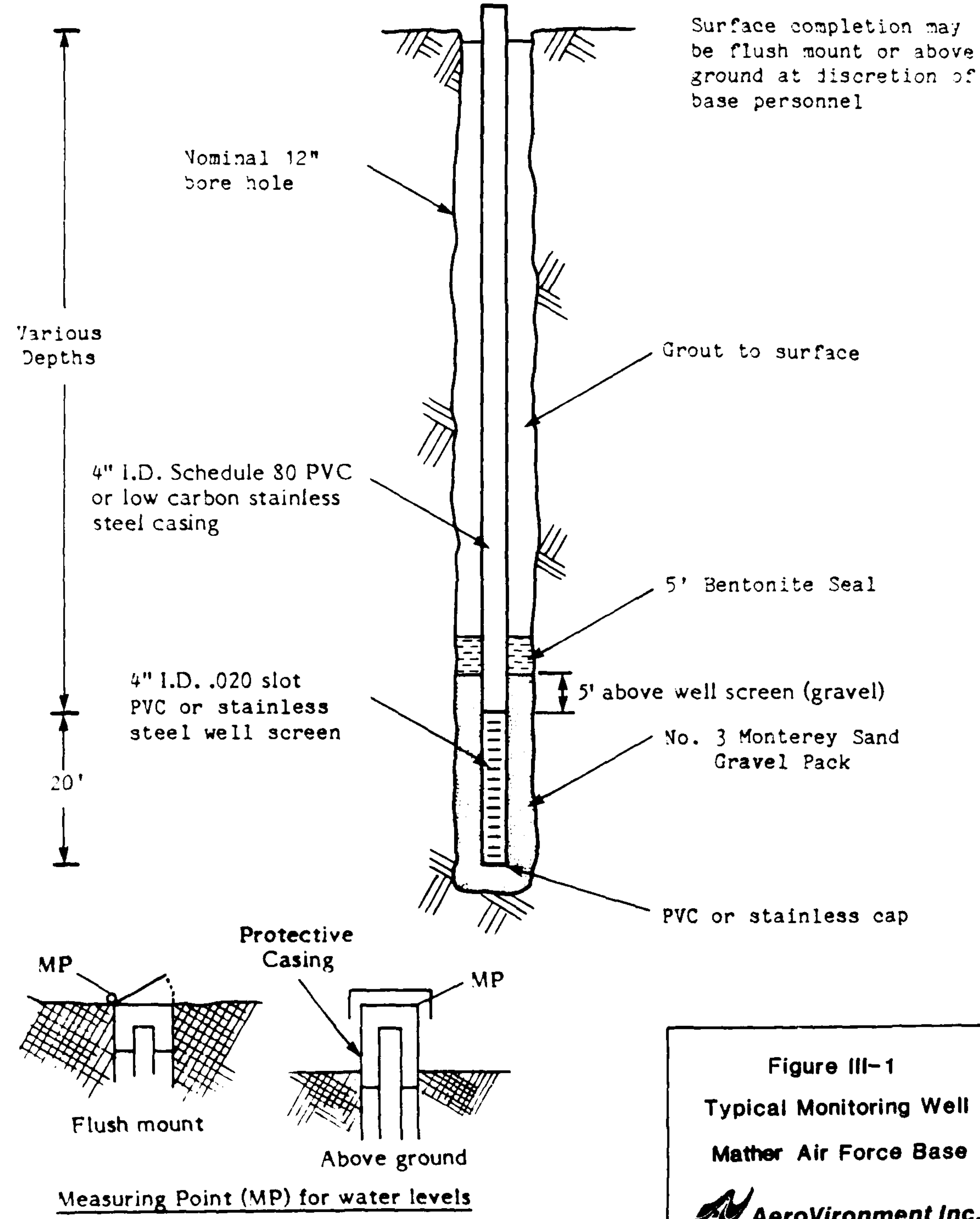

Figure III-1

Typical Monitoring Well

Mather Air Force Base

AeroVironment Inc.

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concrete "christie" boxes with locking steel caps. The remaining wells extended 2-3 feet above ground surface. AV shielded these wells with a steel guard pipe and lid set in a 4-foot square, 4-inch thick concrete pad. For three wells, base officials required three-inch diameter steel guard posts around the pad. These guard posts can be removed to facilitate access for sampling and pump installation. Whenever possible, the pad was sloped away from the well to facilitate drainage.

2. Groundwater Sampling Phase

AV conducted two rounds of groundwater sampling approximately one month apart. A third sampling round (at contractor expense) was later conducted to re-collect samples which had exceeded holding times in the laboratory. Specific sampling information is summarized in Table III-2. The dates of sampling for each round are shown in Table III-3. Each round included 28 wells AV had drilled at the 15 Phase II, Stage 2 sites. Wells (sampling locations) are shown in Figure I-3.

AV collected one set of samples for analysis by AV's lab (Acurex) and a complete set of split samples for USAFOEHL. The California Regional Water Quality Control Board also received a split of all Volatile Organic Analysis samples.

For each sampling round, two field crews were mobilized: a well evacuation crew of two members and a sampling crew of two to three members. The evacuation crew initiated the operation by measuring the static water level with a Powers Electric well sounder. Then five casing volumes were removed from the well with a submersible impeller pump. While pumping, they recorded initial and final readings for water pH, conductivity and temperature. These data are presented in Appendix G. AeroVironment used an Orion Research Model 211 pH meter and a Horizon Ecology type 1840-10 conductivity meter. If the well was a low water producer, or was inaccessible to the pumping vehicle, a 3-1/2 inch diameter, Teflon hand bailer was used to remove these five well volumes. Unless the well needed more time to recover, the sampling crew immediately began the sampling procedure. Two members sampled the well with a 1-7/8 inch diameter

TABLE III-2. Groundwater and Soil Analysis Information.

Parameter		Analysis Method	Bottle Size	Required Preservative(s)
Volatile organics	water	EPA 601/602	40 ml	None
	soil	SW 8010/8020	steel ring	None
Oil and grease	water	EPA 413.2	1 L	1 ml sulfuric acid (H_2SO_4)
	soil	EPA 413.2/3550	steel ring	
Lead	water	EPA 239.2	500 ml (polyethylene)	2 ml nitric acid (HNO_3)
	soil	EPA 239.2	steel ring	None
Dibromochloropropane (DBCP)	water	EPA 608.1	4 L	None
	soil	EPA 608.1	steel ring	None
Ethylenedibromide (EDB)	water	EPA California Method	4 L	None
	soil	EPA California Method	steel ring	None
Nitrates	water	EPA 353.2	1 L (polyethylene)	1 ml sulfuric acid (H_2SO_4)
Sulfates	water	EPA 375.4	1L	None
Chlorides	water	EPA 325.2	1L	None

NOTE: Various references were used in determining the sampling and analytical requirements for this investigation. They are listed in Appendix H.

TABLE III-3. Sampling Timetable.

Date	Well No. Sampled (Does not include duplicate or split samples)
ROUND 1	
12/3/85	28, 29, 30
12/4/85	13, 20, 38, 39
12/5/85	24, 31, 32, 33
12/6/85	16, 19, 21, 22, 23, 25, 26, 34, 35
12/7/85	12, 14, 15, 17, 18, 27C, 37
12/8/85	36
ROUND 2	
1/11/86	12, 14, 15, 30, 39
1/12/86	13, 24, 25, 26, 28, 29, 37
1/13/86	20, 27C, 31, 32, 33, 38
1/14/86	16, 17, 19, 21, 22, 23, 35, 36
1/15/86	18,34
RESAMPLING FOR DBCP AND VOA	
3/23/86	14, 33, 34, 37, 38, 39
3/24/86	12, 22, 23, 24, 25, 26, 35
3/25/86	16, 19, 20, 21, 32, 36
8/18/86	31

Date	Boring Sampled
12/18/86	2 auger rig samples - Site 10A
1/15/86	3 hand auger samples - Site 19

stainless steel bailer and nylon rope pulley system, while the third documented the sampling. A dedicated sampling line was used at each well. The volume of water removed depended on the types of chemical analyses for which the sample was needed. Types of analyses, size of samples, and preservatives required are shown in Table III-2.

The first two bailers of well water were used to rinse the decontaminated sample bucket. Volatile Organic Analysis (VOA) samples were taken first and poured directly from the bailer into the sample bottles. After the required volume for additional parameters was poured into the sample bucket, the sample was funnelled into the appropriate sample bottles. If a metals sample was needed, the water was carefully filtered through a Geotech pressurized, 0.45-micron filter with a glass pre-filter. Then any required preservatives were administered and the sample bottles sealed, labeled and immediately stored in iced coolers.

All the sampling equipment was decontaminated between well samplings. This process included a wash with Alconox detergent, a rinse with drinking-quality water and a second rinse with de-ionized water. We then wrapped the equipment in aluminum foil to ensure cleanliness. The well sampler (i.e., the crew member who handled the sample bailer) wore a new pair of latex surgeon's gloves during the sampling of each well.

After the day of sampling, the field crew packed the samples, including 10% of the split samples for blind quality assurance purposes, with completed chain-of-custody forms. One field blank was prepared for each sampling round. All samples were shipped via Greyhound Bus Lines to Acurex Labs for analyses.

3. Soil Sample Collection

At the FPTA No. 3 site (Site 10A), the Water Development Corporation (WDC) drilled two 10-foot hollow stem auger soil borings on December 18, 1985. This two-man crew operated a Simco Model 2800S drill rig

provided by WDC and collected samples under the supervision of AeroVironment's geologist. He specified the drilling locations, which Mather AFB personnel had proposed after reviewing the geophysical data and aerial photographs. He also specified the 1-foot, 5-foot, and 10-foot depths from which samples were to be taken. As each sample was brought to the surface, the geologist examined it, checked it for organic vapors, capped the ends, sealing it for storage, and logged the soil description. Each sample was sealed quickly to avoid addition or loss of contaminants. Between samples, the drilling crew decontaminated equipment. Throughout the drilling and sampling operation, the geologist monitored ambient air for site safety.

AV used an 18-inch split spoon sampler to collect the soil samples from the 10-foot borings (Figure III-2). With this system the sampler is lowered down the center of the hollow stem augers, after the bit (or plug) is removed. The sampler was driven 18 inches into the undisturbed soil directly below the open hole. Sampling always occurs ahead of the augers. The sampler is driven into the ground by a 140-pound hammer which falls 30 inches. The field geologist counts the number of times the hammer falls to advance the sampler each six-inch segment. This number is called the "blow count" and gives some indication of the soil's stiffness. It is recorded on the boring logs in Appendix D.

Before each use, the sampler was opened (split down the middle) and three 6-inch long, 2-inch OD mild steel tubes were placed inside it as liners. When the reassembled sampler was driven into the ground, an 18-inch column of soil was pushed up into the rings. The sampler was then pulled out of the hole and opened. The three rings were marked with the depth to which they had been driven. The uppermost ring was thrown out, because it often contained sluff material which fell into the bottom of the hole. The bottom two rings were prepared for laboratory analysis. The field geologist quickly removed the rings from the sampler, visually inspected the soil, covered both ends with aluminum foil, capped the ends with airtight plastic caps and sealed the caps with electrical tape. Afterwards, the sample was labeled for laboratory identification and logged on the boring log. After marking and logging, the field geologist stored the sample on ice in a picnic-type cooler. This method of sampling provided a basically undisturbed, airtight soil sample to be shipped to the laboratory.

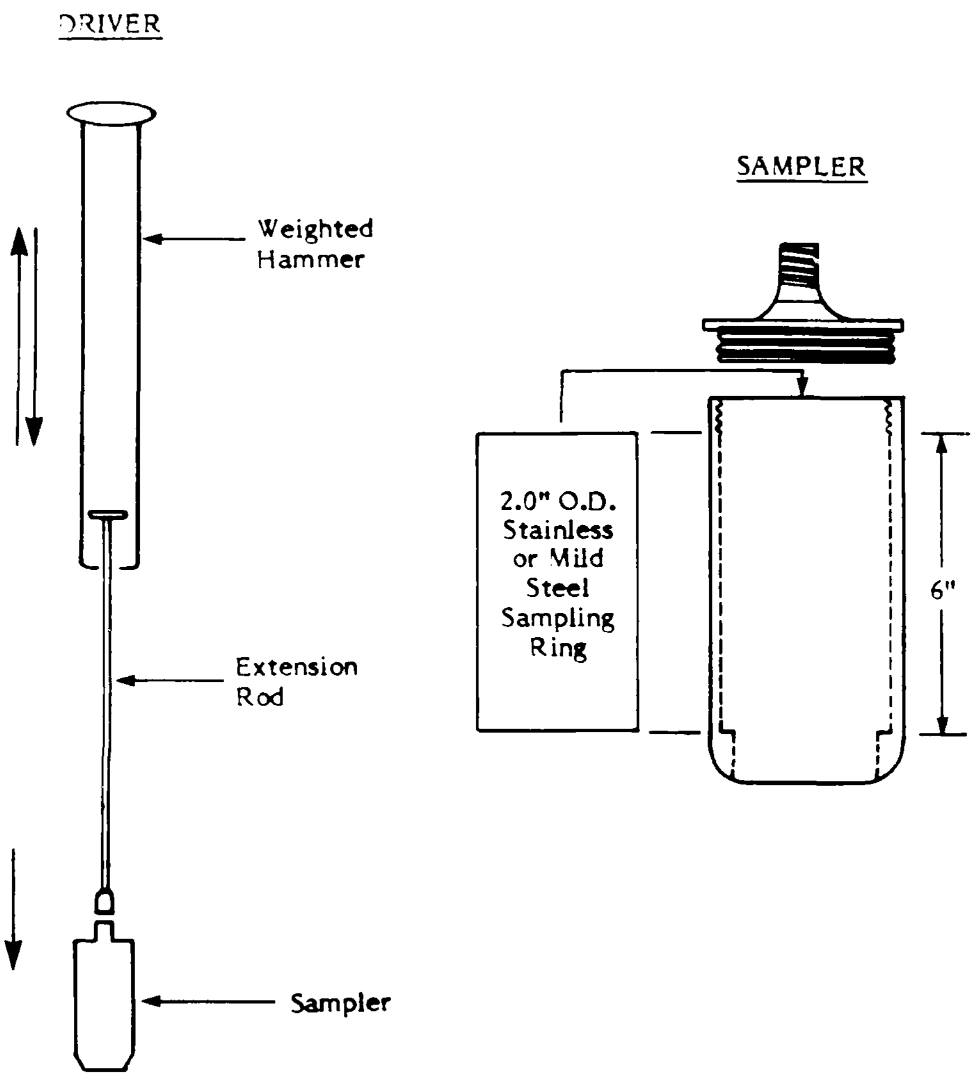

Figure III-2

Hand Sampling Device

Mather Air Force Base

AeroVironment Inc.

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The AV project team considers the "ring sampling" method used at Mather AFB to be superior to the traditional split-spoon sampling method used on many EPA drilling programs. Split spoons without rings require reusing the sampler, opening and mixing the soil sample, and transferring the sample into the sample jar. The ring method *virtually eliminates the sampling* errors of cross-contamination, sample mishandling, and loss of volatile compounds.

As previously mentioned, this method collects three discrete, six-inch samples at each sample location. The bottom ring was used for analysis by AV's laboratory (Acurex). The middle ring was saved for a quality assurance (QA) sample and the upper ring (possibly filled with foreign soil) was discarded. The QA samples were used, first, for Mather AFB personnel to select 10% splits for the USAFOEHL Laboratory and, second, for AV to send 10% blind duplicates to Acurex. Because the QA samples were actually from the bordering six-inch column of soil, they were not true splits. However, AV believes that the decreased chance of cross-contamination in the samples is more important than obtaining a true split. Soils six inches away should correlate well enough to check laboratory precision. (Further discussion of the QA program is given in Section III-E.)

The steel rings used at Mather AFB were always new to prevent cross-contamination. Prior to their use, the rings were thoroughly cleaned with a paper towel to remove any dust or moisture from the inner surfaces.

The sampler was washed with Alconox detergent and water, rinsed with drinking quality water, and reloaded with new cylinders between samples. The field geologist wore latex gloves whenever he handled the samples. The drilling tools were steam cleaned between holes to avoid cross-contamination. All holes were grouted to the surface with cement at the end of drilling in each area.

Base personnel also identified three shallow soil sampling locations at the Fuel Tank Sludge Burial site. The samples were collected from inside the fuel storage tank berm in place of deeper borings (the drill rig could not get inside the berm). Samples were collected at the ground surface and at a depth of two feet at each location. Two AV personnel collected these samples on

January 15, 1986, using a hand auger and hand-operated slide hammer sampler. They were responsible for collection, logging, air monitoring and equipment decontamination.

Hand-augered samples were obtained in much the same way as samples collected with the drill rig. The sampler (Figure III-3) held a single 6-inch cylinder, 2 inches in ID, and was driven into the soil with a slide-hammer attachment. AV used sample collection rings machined from mild steel. After a sample was collected, it was removed from the sampler in its collection ring, the ends were covered with aluminum foil, capped, and taped. The sample was then logged. The sampler was washed with Alconox and water and rinsed with drinking quality water between samples. After the surface sample was taken, the boring was advanced to the desired depth with a hand auger and the soil sampler was again used to obtain a 6-inch core at the bottom of the hole. The hand auger was cleaned between each hole using the same procedure used for the sampler.

Because the shallow samples at this site were depth-specific, the QA samples were taken from a separate hole immediately adjacent to the original hole. This allowed the "split" samples to be taken at the same depths as those taken for AV's lab (Acurex). As with the samples from the deep borings, the QA samples were not true splits but are considered to be less prone to field error. Mather AFB personnel selected 10% of the QA soil samples for shipment to the USAFOEHL lab. AV then selected approximately 10% of the QA samples for submission to Acurex as blind duplicates.

No background samples were collected during the soil sampling program. The objective of the soil sampling at Mather was to look for high levels of contamination in isolated situations. Levels should either be near zero or highly elevated. Background concentrations are assumed to be near zero for organic parameters (except the oil and grease analytical method which detects natural organics in soil) and up to 50 mg/kg for lead (OEHL, 1985).

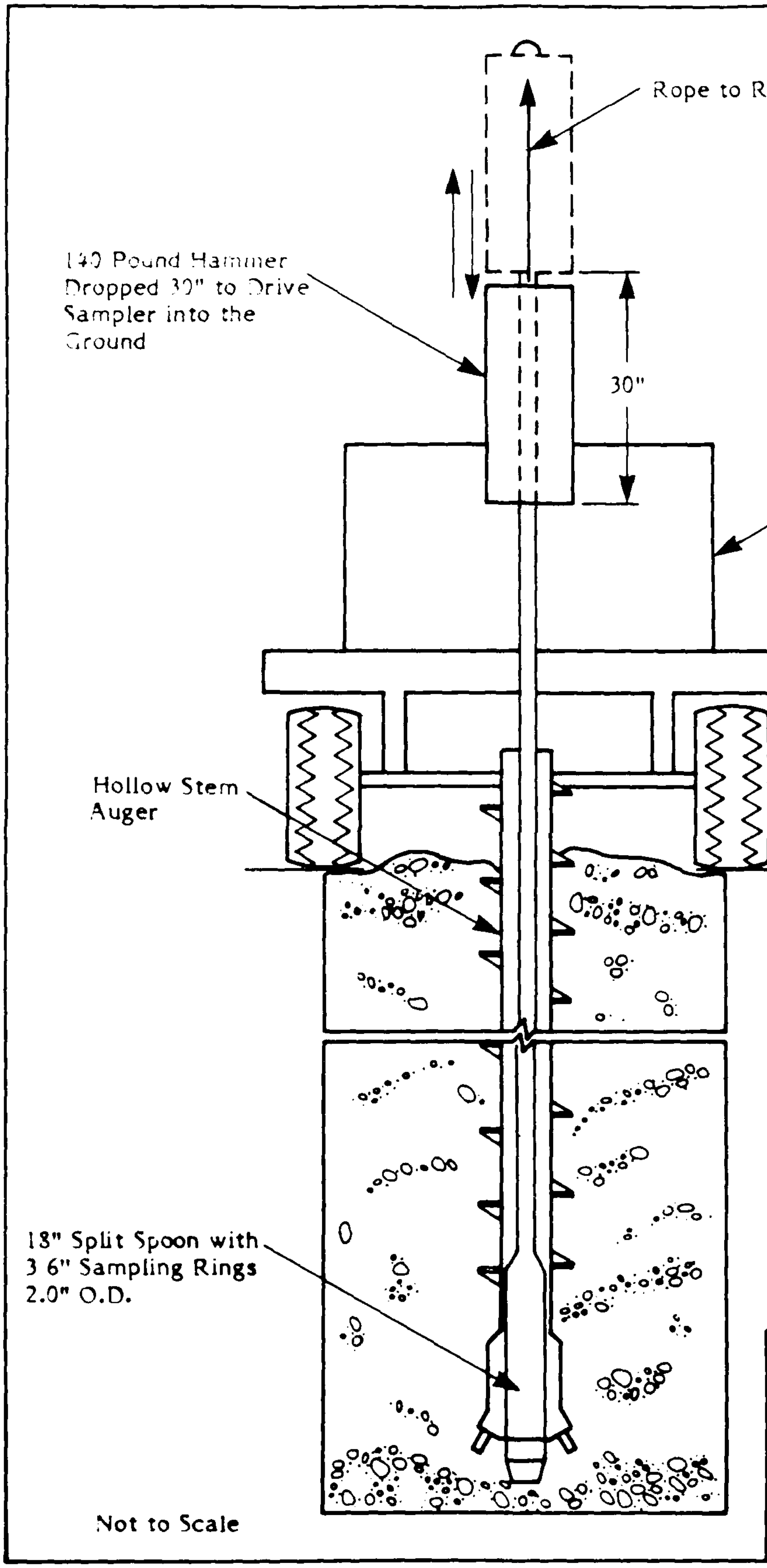

Figure III-3

Auger Sampling System

Mather Air Force Base

AeroVironment Inc.

4. Geophysical Program

Geophysical surveys were conducted at eight sites within Mather AFB prior to the start of the drilling phase. Field work was completed between September 23 and 27, 1985. The objective of the surveys was to establish data needed to define the boundaries of four abandoned landfills and four sites possibly contaminated with petroleum products. Each site was considered a separate problem and no attempt was made to correlate one site with another. The results were used by AeroVironment to select optimum locations for groundwater monitoring wells. A summary of geophysical activities is found in Table III-4.

Two geophysical methods were used to obtain data. The terrain conductivity method, which uses the principle of electromagnetic induction to measure soil conductivity, mapped lateral changes in the conductivity of the subsurface. Changes in conductivity can be caused by changes in geologic feature (groundwater zones, shallow rock, and fault/fracture zones) or can be the result of cultural activities (buried pipelines, drums, trenches filled with metal objects and chemical spills). Buried features can be located by the terrain conductivity method, if the feature shows a dielectric contrast when compared to its surroundings.

The second geophysical method, an impulse ground-penetrating radar (GPR) system was used to collect high resolution subsurface data along most of the profiles traversed by the conductivity survey. The GPR uses high frequency electromagnetic waves to map the location of buried reflectors (geologic interfaces, top of groundwater, and metal objects). Radar data can also define the location of buried features that have a dielectric contrast relative to their surroundings, but detection is based on the reflection of waves.

GPR was not used at Site 19 (fuel tank sludge burial site), because the graphic recorder sparks during normal operation and this was thought to represent a fire hazard in this fuel storage area.

TABLE III-4. Summary of Geophysical Survey Activities.

Site No.	Conductivity Profiles	Conductivity Stations	Stations Spacing (ft)	Amount of Coverage (linear ft)	Background Conductivity (mmhos/m)	Maximum Conductivity (mmhos/m)	Radar Profiles
1	10	300	20	6,430	13	57	7
3	8	280	50	11,15[illegible]	18	50	8
4	7	159	50	6,30[illegible]	26	80	4
5	8	253	50	[illegible]	15	50	9
8	5	178	20	3,5[illegible]	14	22	5
10	9	106	20	1,920	27	69	8
19	9	110	5	495	--	90	No radar
20	4	35	10	380	--	100	4
TOTAL	60	1,421	--	35,015	--	--	45

NOTE: A background conductivity value for each site was statistically calculated as the mode of the field data set. Background values for Sites 19 and 20 were not calculated because all the measurements were disturbed by a multitude of nearby, metal cultural features.

As a result of the geophysical program, monitoring well locations near the sites investigated were sited at optimum locations, and two of the landfills (Sites 3 and 4) were found to be larger than first expected. Based on the geophysical studies the Bioenvironmental Engineer believed that shallow soil borings should be conducted at Sites 10A and 19 as planned in the Statement of Work.

5. Laboratory Interface

All samples collected at Mather AFB were analyzed at Acurex Corporation's Energy & Environmental Division. Acurex's Analytical Laboratory is certified by the California Department of Health Services and is a contract laboratory for the U.S. Environmental Protection Agency.

Samples collected at Mather AFB were shipped via Greyhound bus and delivered to the laboratory overnight. Whenever possible, AeroVironment contacted the lab the morning after sample shipment to confirm receipt. All chain-of-custody documents were checked against samples received by the laboratory sample custodian, who signed each form and returned them to AeroVironment.

AeroVironment's field personnel kept in close communication with laboratory personnel throughout the field program: (1) to ensure all samples shipped to the laboratory had arrived in good condition, (2) to coordinate sampling activities with the laboratory to make sure samples were able to be processed within specified holding times, and (3) to identify errors in sampling, preservation or analysis quickly, so that they could be rectified.

AeroVironment personnel visited the laboratory on several occasions and met with laboratory personnel to discuss the selected methods, disposition of samples, potential problems, quality assurance, and data reporting. During the course of the field program, this exchange led to the detection and quick correction of problems before they became serious. Some examples are:

- Several Method 602 and DBCP samples which had exceeded the seven-day holding time requirement for analysis of "602" samples and extraction of DBCP samples were identified and quickly resampled. Acurex and AeroVironment worked together to develop mutual guidelines to prevent additional missed holding times.

- AeroVironment and Acurex worked closely on reviewing the analytical data and identifying errors and inconsistencies, all of which were quickly resolved. The goal was to produce a data package which was as accurate and error-free as possible.

An AeroVironment team conducted a quality assurance audit of the laboratory in April 1986. Its purpose was to evaluate the laboratory's methods and procedures as these related to the analysis of Air Force IRP samples submitted by AeroVironment to ensure that the resulting data were true and valid. This audit is discussed as part of Section III.E, Quality Assurance Program.

C. Field Instruments (Measuring Devices)

During the geophysical surveys, Earth Technology used their own instrumentation to perform conductivity and ground-penetrating radar measurements. These instruments were calibrated and operated according to manufacturers specifications. Conductivity measurements were made with a Geonics EM-31 terrain conductivity meter. The instrument's transmitting and receiving coils act as magnetic dipoles. Small amplitude eddy currents are induced in the ground when alternating current is applied to the transmitter coil. The secondary magnetic fields caused by the eddy currents are detected with the receiver coil. The ratio of the received signal to the transmitter's primary field is proportional to the soil conductivity. Field measurements are rapid, because no direct connection with the ground is required.

The EM-31 consists of a 12-ft-long boom operated by one person. This boom contains both the transmitter and receiver coils. Because of its short coil

separation, the EM-31 gathers data predominantly from near-surface materials. The effective penetration depth, in the normal operating mode (vertical dipoles), is about 15 ft. The meter's sensitivity is ± 1 mmhos/m.

Ground penetrating radar data were taken with a Geophysical Survey System, Inc., SIR System 8 ground-penetrating radar. Impulse radar radiates repetitive, short time-duration electromagnetic pulses into the earth from a broad band width antenna placed close to the ground surface. The equipment functions as an echo-sounding system using radar pulses of only a few nanoseconds to detect and measure the location and depth of reflecting discontinuities in subsurface soils. Continuous profiles are generated by towing the antenna along the profile and displaying the reflected radar signals on a graphic recorder. The effective penetration depth at these sites was between four and six feet.

During the drilling phase, a gas alarm (O_2/explosimeter) was always on site and used to ensure that the ambient air remained at an acceptable oxygen level. The drill hole and drill cuttings were monitored with an organic vapor analyzer (OVA) that measures the presence of organic vapors. Once the well was drilled, a well sounder determined the depth at which the water table was encountered.

The Gastech Protector Model 1562 Portable Gas Alarm used during this phase of the Mather AFB project can detect and indicate combustible gas concentrations up to the lower explosive limit. If gas concentration exceeds a preset level, it emits a characteristic audible signal. It also analyzes for oxygen over the range of 16 to 22% and emits a different signal if the oxygen concentration drops below a preset level. Combustible gas is detected by a diffusion head containing a catalytic element. Oxygen is detected by an electrochemical oxygen cell installed in the same head with the combustibles detector.

The Foxboro Century Model organic vapor analyzer (OVA)-128 GC portable flame ionization detector used is sensitive to organic vapors delivered to it by means of diaphragm pump. It is extremely sensitive and monitors total

organic vapors to parts per billion (ppb) levels. The detector is composed of a hydrogen delivery system, a sample delivery system, and an electronic amplification and display system. In the survey mode, the air sample is delivered continuously to the detector chamber. When an organic vapor is exposed to the hydrogen flame via the air flow, the molecules ionize and a current is carried between the detector electrodes. The current is proportional to the concentration of the vapor in the sample. Different compounds will ionize to varying extents in the flame, thus; the meter response of the OVA for a given compound is expressed relative to a standard (methane). The OVA was calibrated on a daily basis, using a known methane standard and background air.

The Powers Electric Company Well Sounder is a 200-foot probe cable labeled at 5-foot intervals to monitor the depth at which the top of the water table is encountered. The end of the cable consists of two electrical probes connected by one foot of lead weights. When both probes are submersed in groundwater, an electrical current is induced and the meter registers in milliamperes.

During the groundwater sampling phase at Mather AFB, pH and conductivity meters characterized the sample water. The Orion Research Model 211 Digital pH meter uses a combination electrode probe to determine the acidic or basic properties of the sample water. Two buffer solutions were used daily to calibrate the system and the probe was decontaminated with deionized water after each use.

The Horizon Ecology Company Type 1840-10 Conductivity Meter, a self-contained dip-style probe with tungsten electrodes, measures total ionized substances in solution. The meter displays conductivity from 0 to 20,000 micromhs/cm in five ranges. The temperature compensation is automatically corrected to 20°C by an internal thermistor network in the probe. It was decontaminated with deionized water after each use.

The Geotech 2.4 Liter Barrel Filter is a pressure filtration unit which filters all particles of sizes down to 0.45 microns. During filtration, the barrel is sealed and gradually pressurized to pressures not exceeding 40 psi. Before reaching

the 0.45 micron filter, the sample goes through a fiberglass pre-filter to seive out any large particles. This instrument is decontaminated after every use.

All equipment used during this project was properly maintained, calibrated and operated, according to the procedures outlined by the manufacturer of each piece of equipment.

D. Daily Activities

The drilling and sampling activities are summarized in Table III-1 and Table III-3. A more detailed daily log is found in Appendix L.

E. Quality Assurance Program

To assure the quality of the measurement data, a sampling and analysis quality assurance/quality control (QA/QC) program was implemented. The objectives of this program were:

- To monitor the precision of the sampling program by comparing blind field duplicate data with laboratory duplicate QC data.
- To monitor the integrity of the analytical data. Field quality control samples were blind in order to eliminate the potential for laboratory bias.
- To monitor the sampling methods for evidence of sample contamination through the use of field blanks.
- To identify and minimize sources of error in the sampling program.

A more complete description of the quality assurance program is found in Appendix M.

IV. DISCUSSION OF RESULTS AND SIGNIFICANCE OF FINDINGS

A. Discussion of Results

1. Geology

Mather AFB is on the eastern edge of the Sacramento Valley. The terrain is gently rolling hills with elevations ranging from 60 feet above sea level in the southwest to 160 feet in the northeast. The formations encountered during our drilling program were deposited as outwash from streams that originated in the Sierra Nevada Mountains to the east. They gently dip toward the center of the valley to the west.

Three cross-sections have been generated from the drilling data to illustrate the stratigraphy found beneath the base. Figure IV-1 shows the locations of the three sections drawn for Mather AFB. Figures IV-2, 3 and 4 are the cross-sections themselves. The cross-sections were drawn using information from the boring logs included in Appendix D.

The uppermost unit is the Victor Formation (mapped as QV in the geologic cross-sections). This unit is unconsolidated conglomerate with variable amounts of clays, silts, and gravels. Generally, it is present as silty sands and gravels with occasional clay or gravelly clay zones. The Victor Formation was found in most of the western half of the base, and isolated outcrops were found in the northeast corner near Sites 3, 4, and 5. In most areas, a hard pan had developed two to three feet below the surface. This greatly reduces the potential for infiltration of water from the surface except in areas in which the ground has been disturbed, such as landfills.

The South Fork or Arroyo Seco Gravels are found directly beneath the Victor Formation. These gravels (mapped as Qg) were deposited by the South Fork of the ancestral American River. As the name suggests, the material is mainly pebble to cobble size with medium to very coarse sand. Occasional zones of cemented sands were found in with the gravels, which will retard but not preclude

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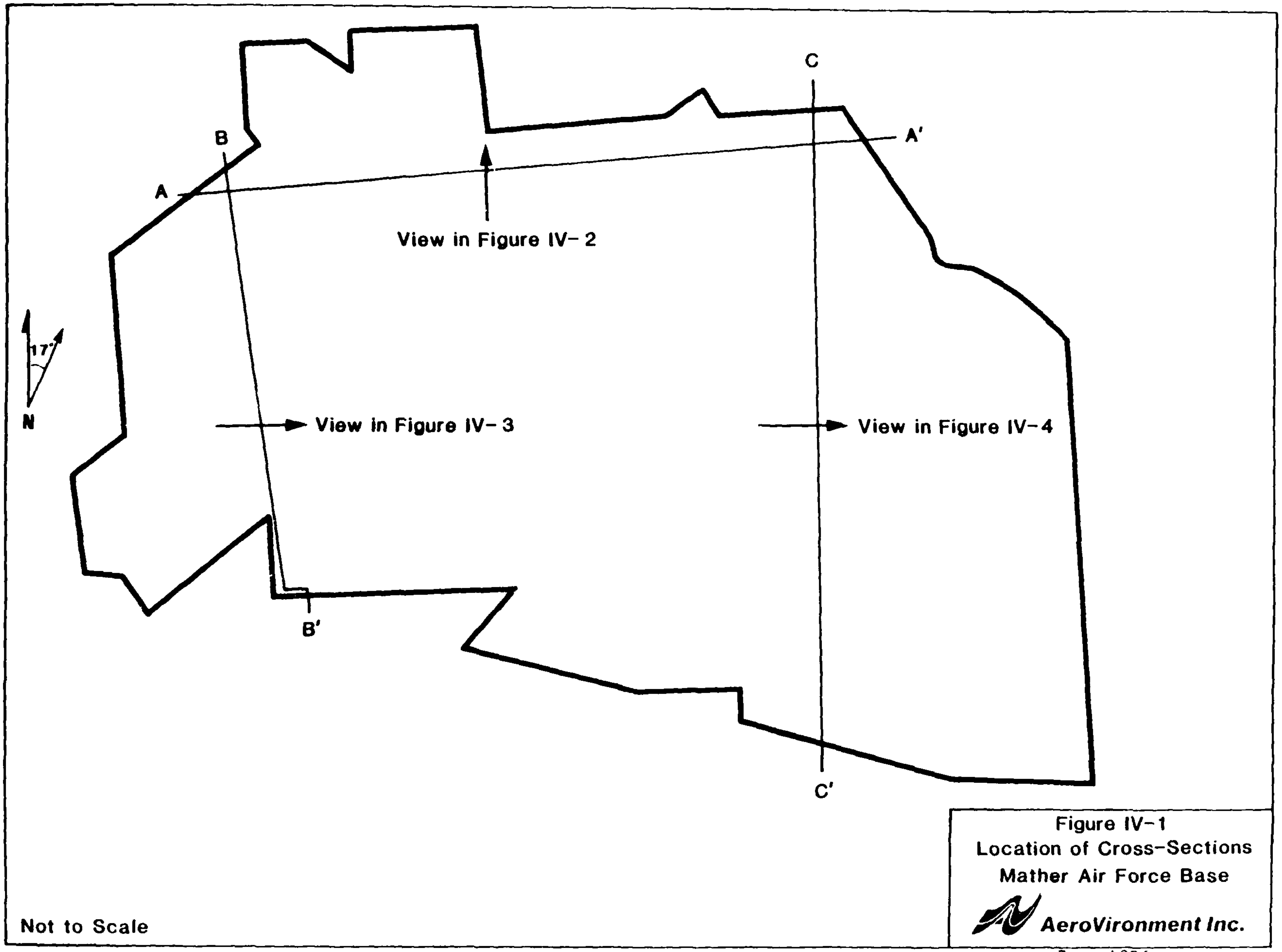
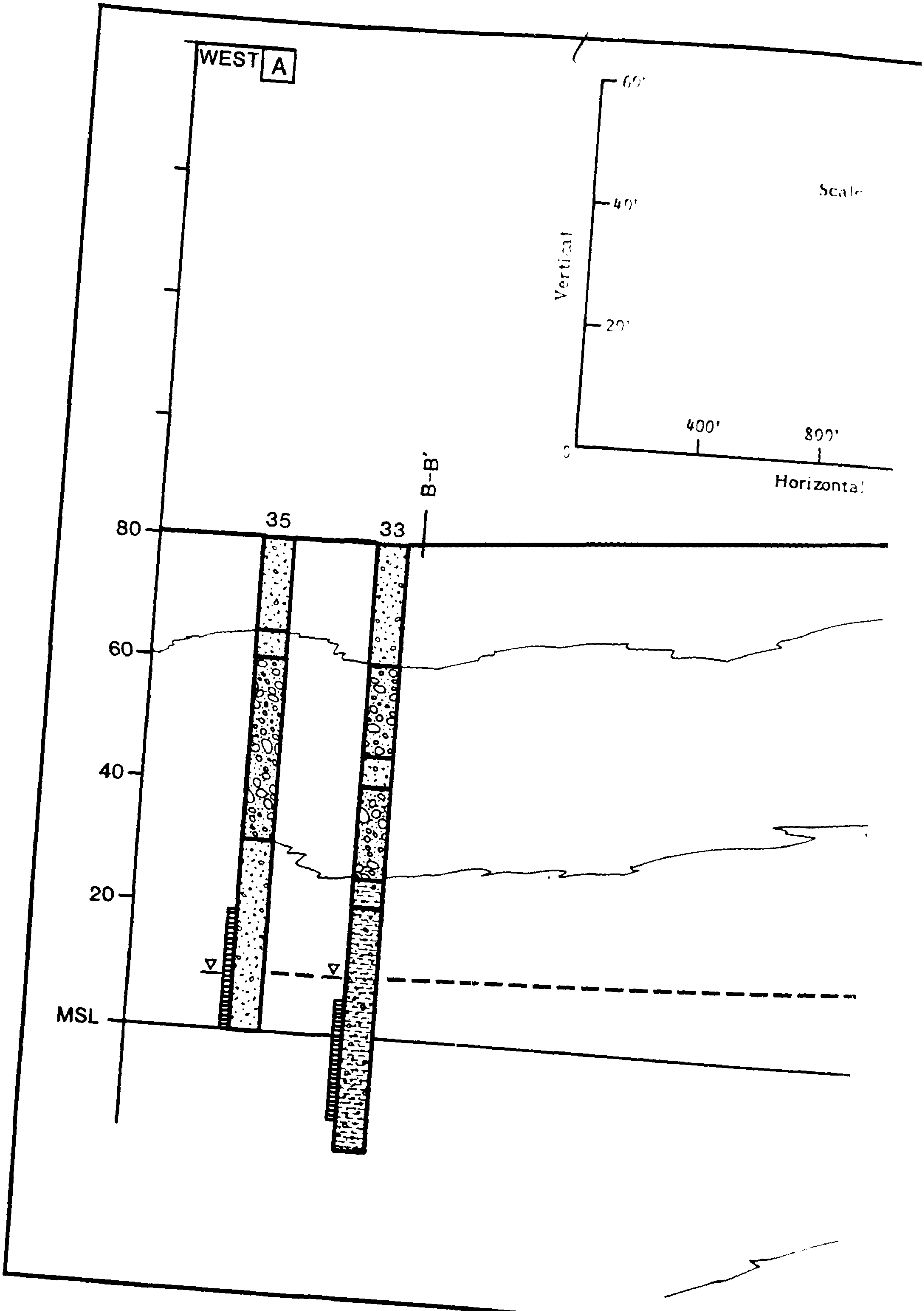


Figure IV-1
Location of Cross-Sections
Mather Air Force Base

AeroVironment Inc.

June 1986



WEST
A
Scale
Vertical
60'
40'
20'
0
400'
800'
Horizontal
B-B'
35
33
80
60
40
20
MSL

LEGEND

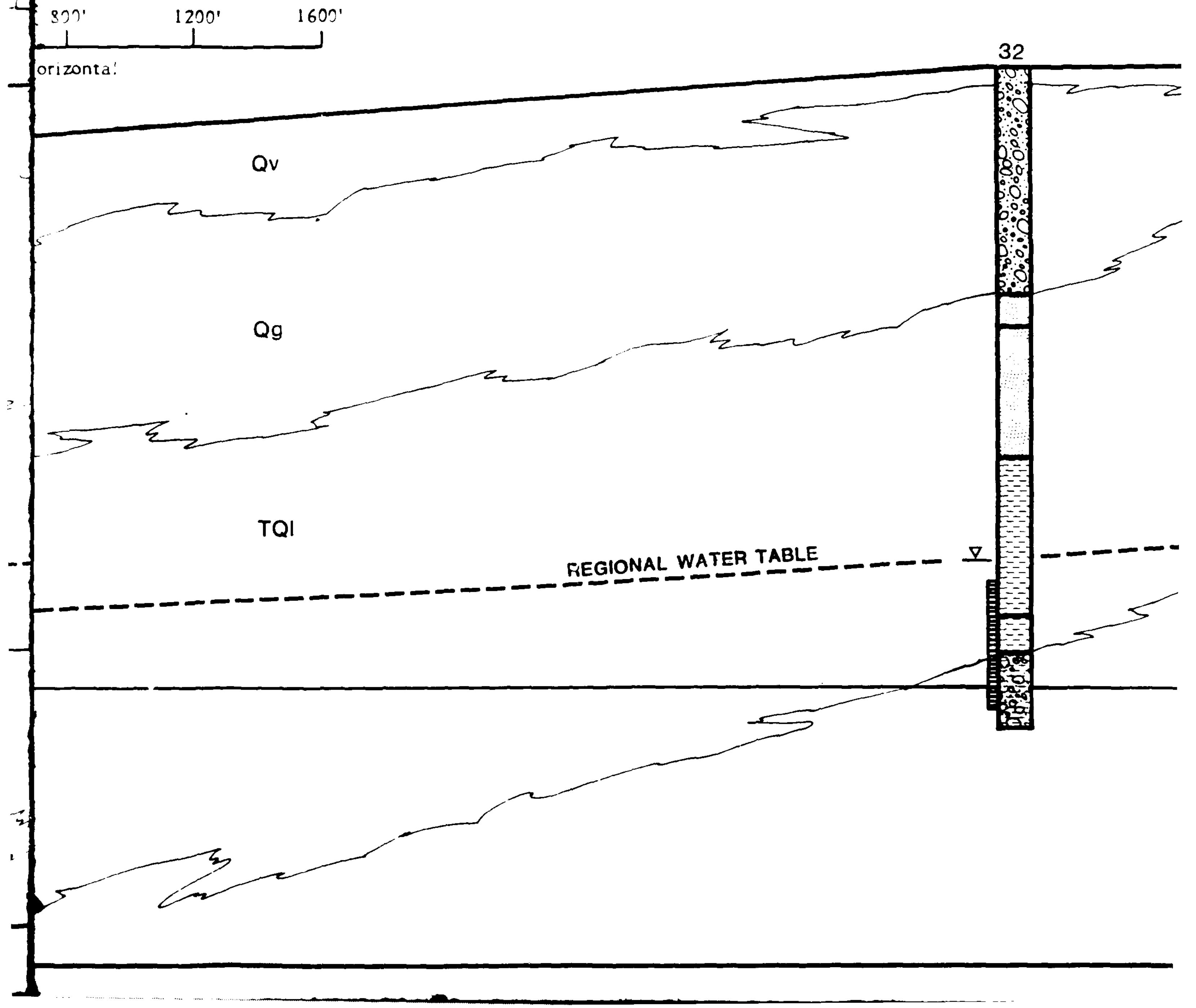
Qv - Victor Formation: Unconsolidated conglomerate. Generally silty sands and gravels with occasional clay or gravelly clay zones.

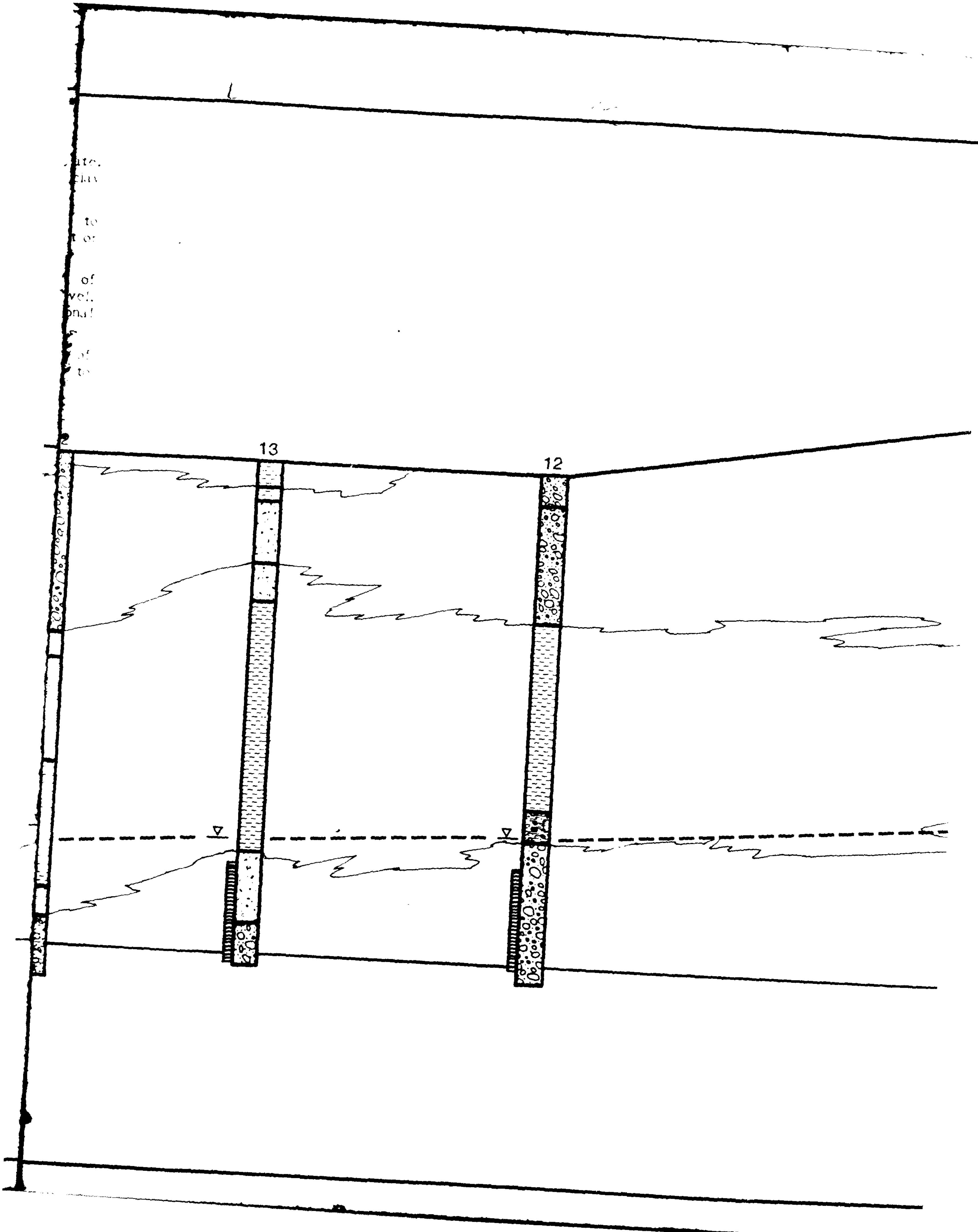
Qg - South Fork or Arroyo-Seco Gravels: Cobble to gravel, with medium to very coarse sand, little silt or clay.

TQl - Laguna Formation: Heterogeneous mixture of interbedded sands, clay, clayey sands, and gravel. Matrix material is clay to sand with occasional cementation.

Ptm - Laguna-Mehrten Transition Zone: Upper unit of Mehrten Formation composed of coarse sand to cobbles.

Scale

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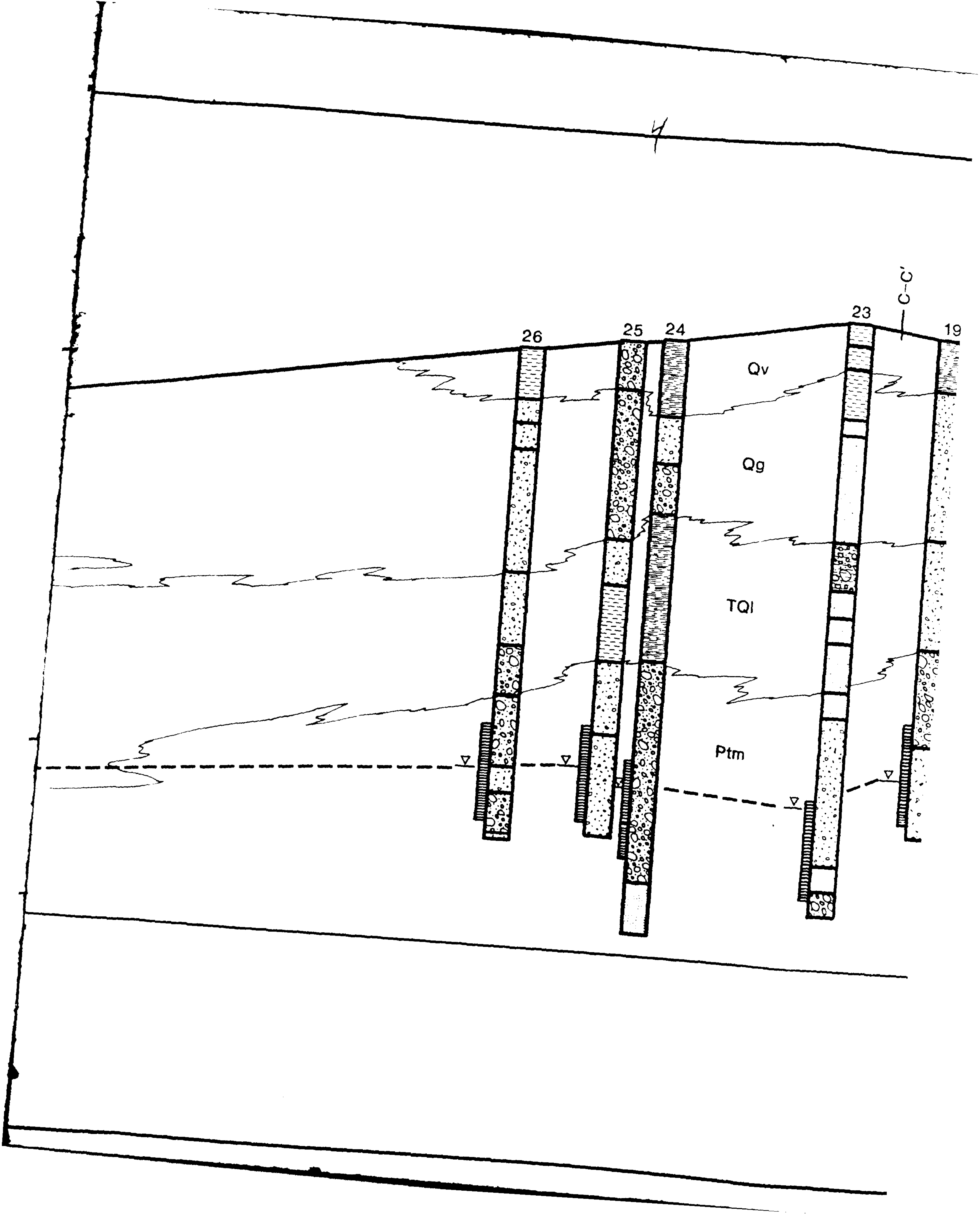
12



26
25
24
23
C–C'
19
Qv
Qg
TQl
Ptm

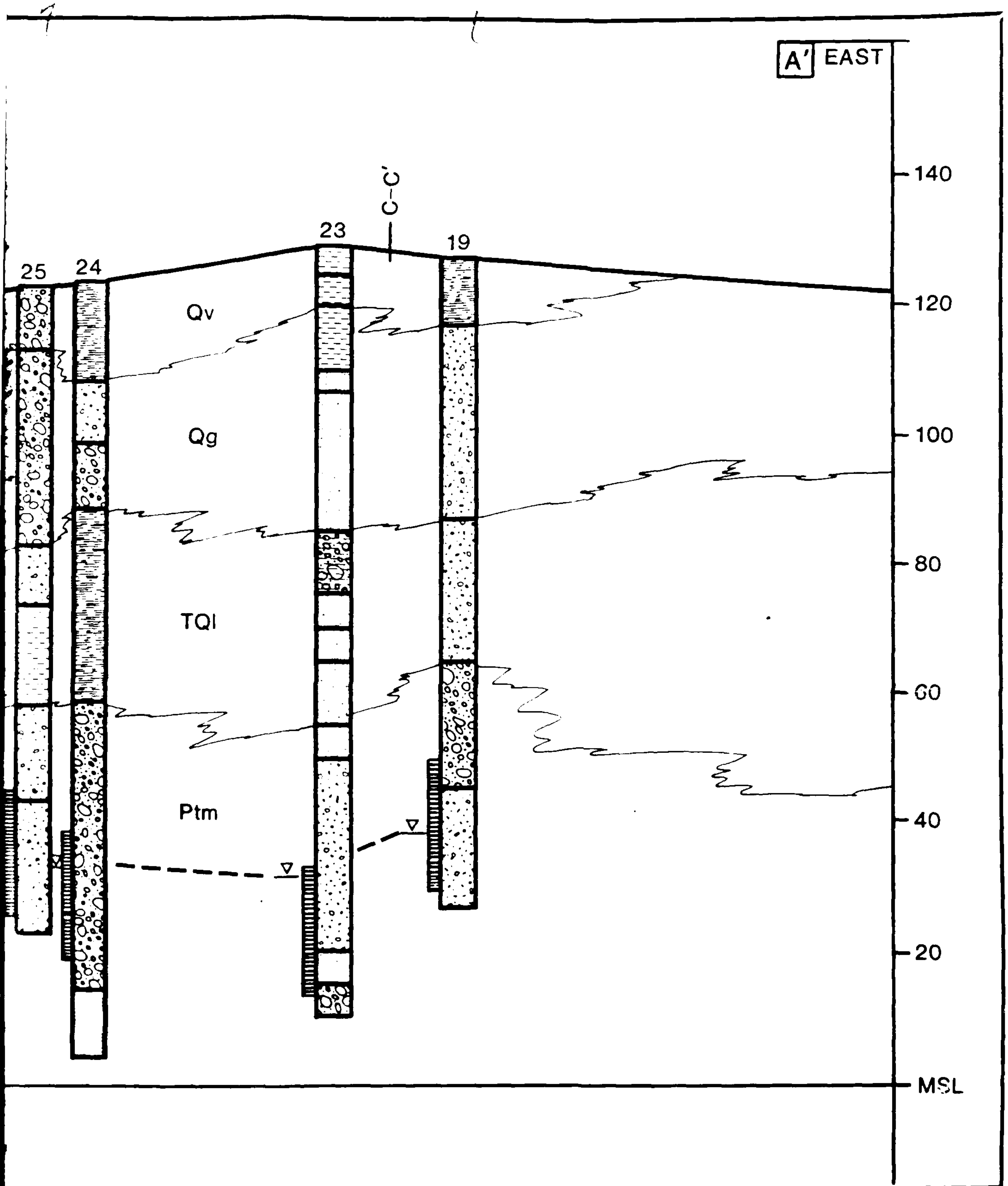
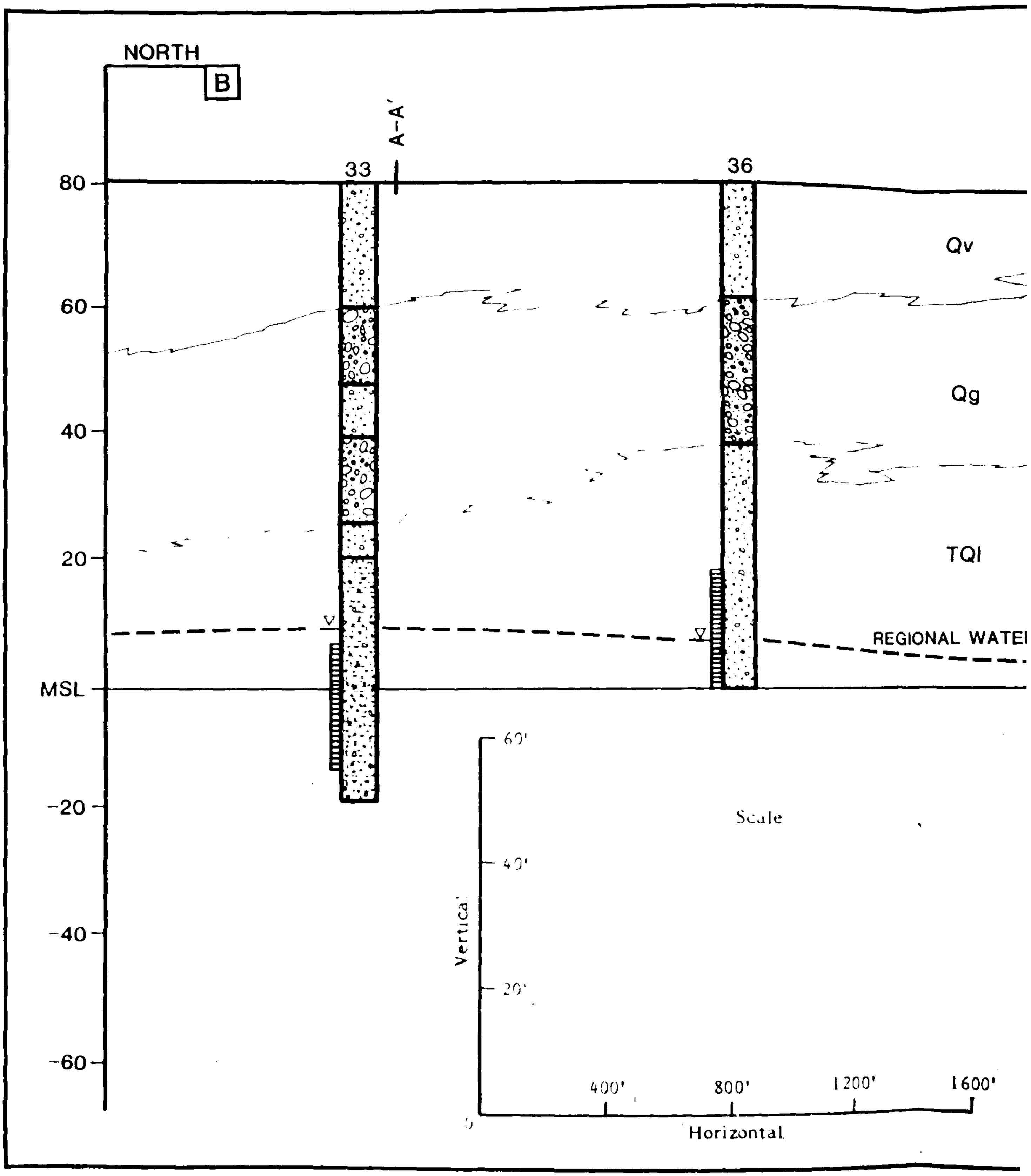


Figure IV–2

Geologic Section A–A'

Mather Air Force Base

AeroVironment Inc.



NORTH
B
A–A'
33
36
80
60
40
20
MSL
-20
-40
-60
Qv
Qg
TQl
REGIONAL WATE
Scale
Vertical
60'
40'
20'
0
400'
800'
1200'
1600'
Horizontal

AD-A186 091 INSTALLATION RESTORATION PROGRAM PHASE 2 CONFIRMATION/QUANTIFICATION STAG..(U) AEROVIRONMENT INC MONROVIA CA 22 JUN 87 AV-FR-86/501-VOL-1 2/2

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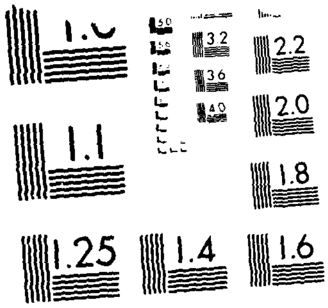
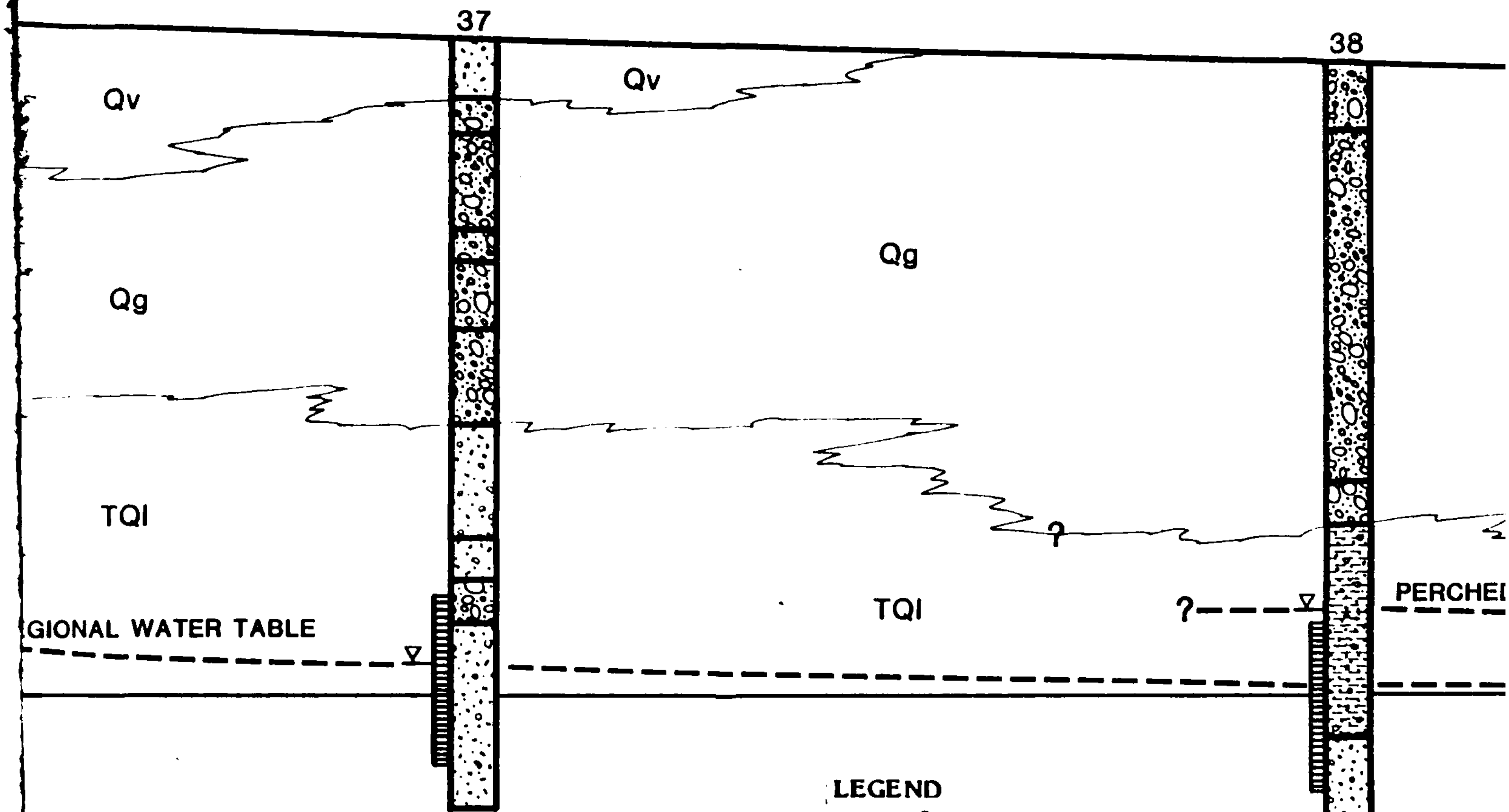


MICROCOPY RESOLUTION TEST CHART



LEGEND

Qv - Victor Formation: Unconsolidated conglomerate. Generally silty sands and gravels with occasional clay or gravelly clay zones.

Qg - South Fork or Arroyo-Seco Gravels: Cobble to gravel, with medium to very coarse sand, little silt or clay.

TQl - Laguna Formation: Heterogeneous mixture of interbedded sands, clay, clayey sands, and gravel. Matrix material is clay to sand with occasional cementation.

Ptm - Laguna-Mehrten Transition Zone: Upper unit of Mehrten Formation composed of coarse sand to cobbles.

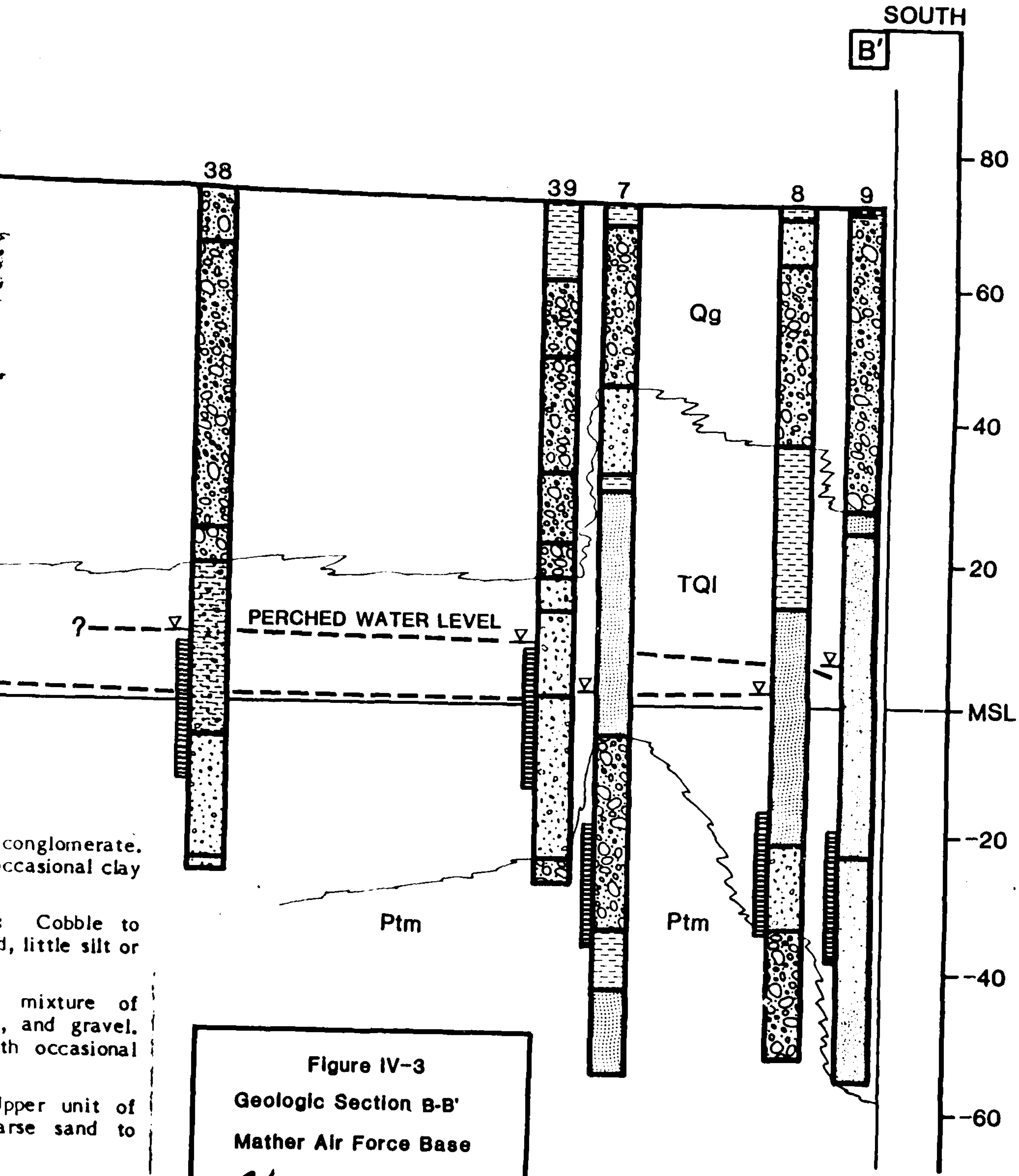
1600'

Fi

Geologic

Mather A

Aer



conglomerate.
occasional clay

: Cobble to
Ptm d, little silt or

mixture of
s, and gravel.
ith occasional

IV-
Upper unit of
ction arse sand to
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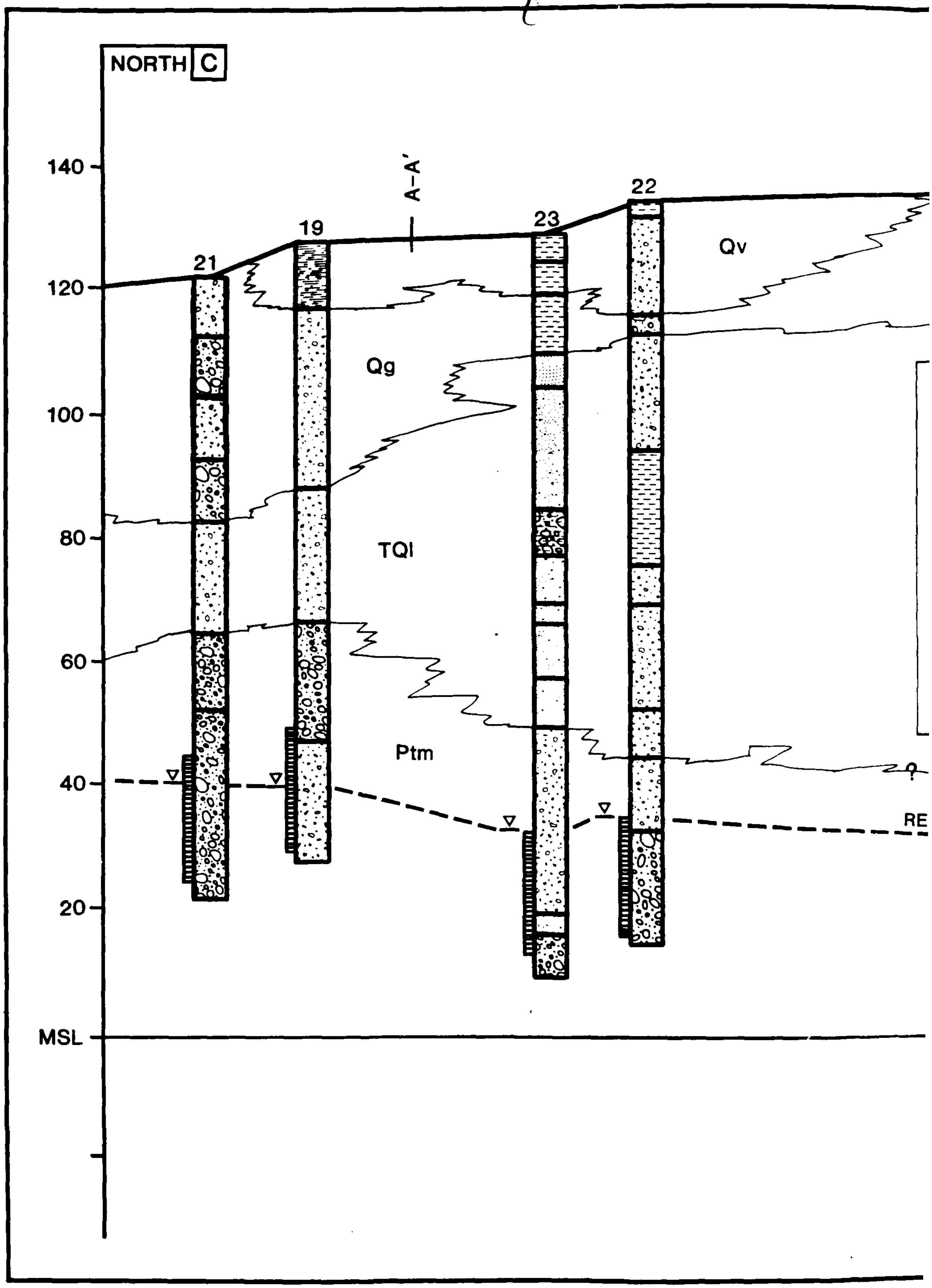
Figure IV-3

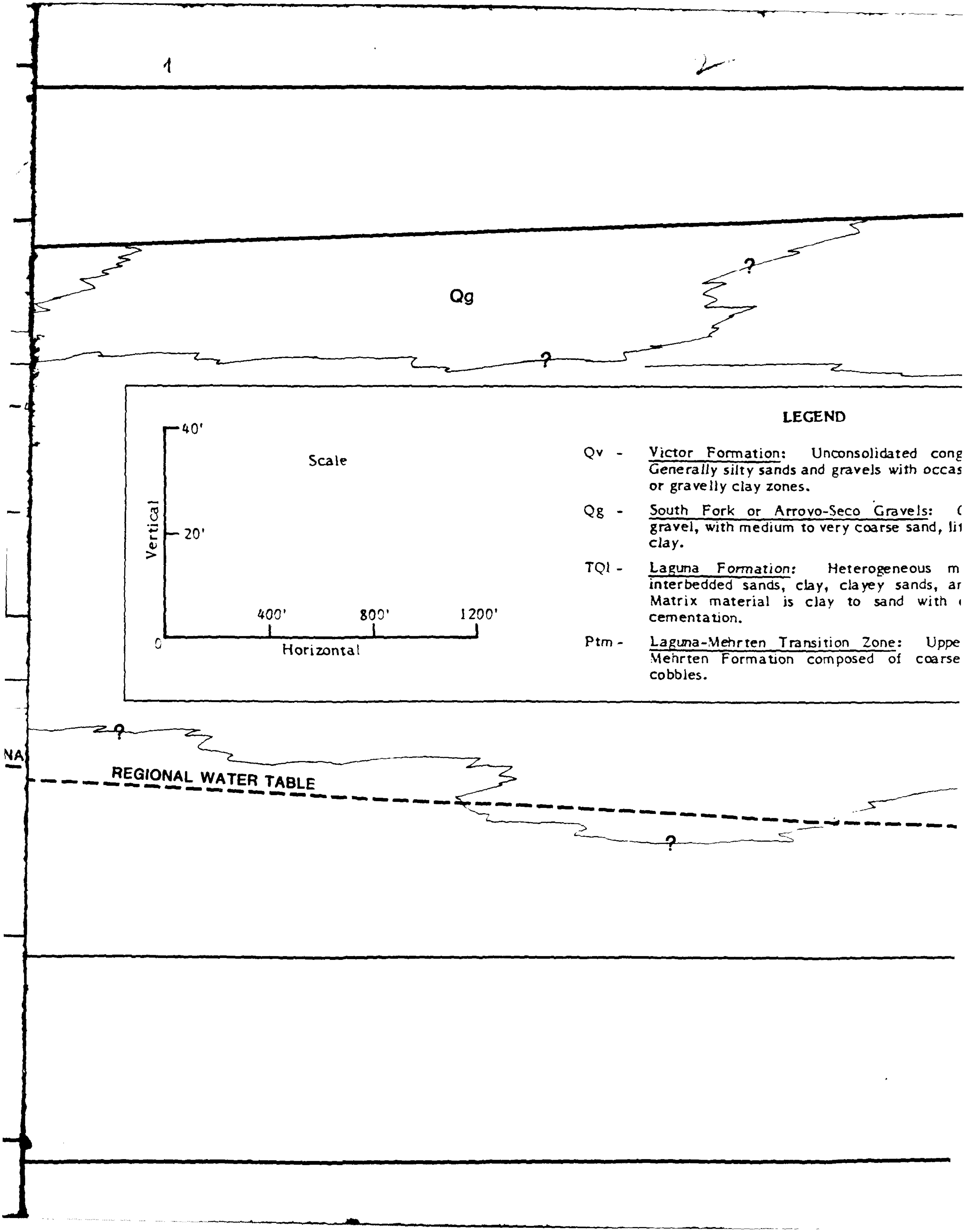
Geologic Section B-B'

Mather Air Force Base

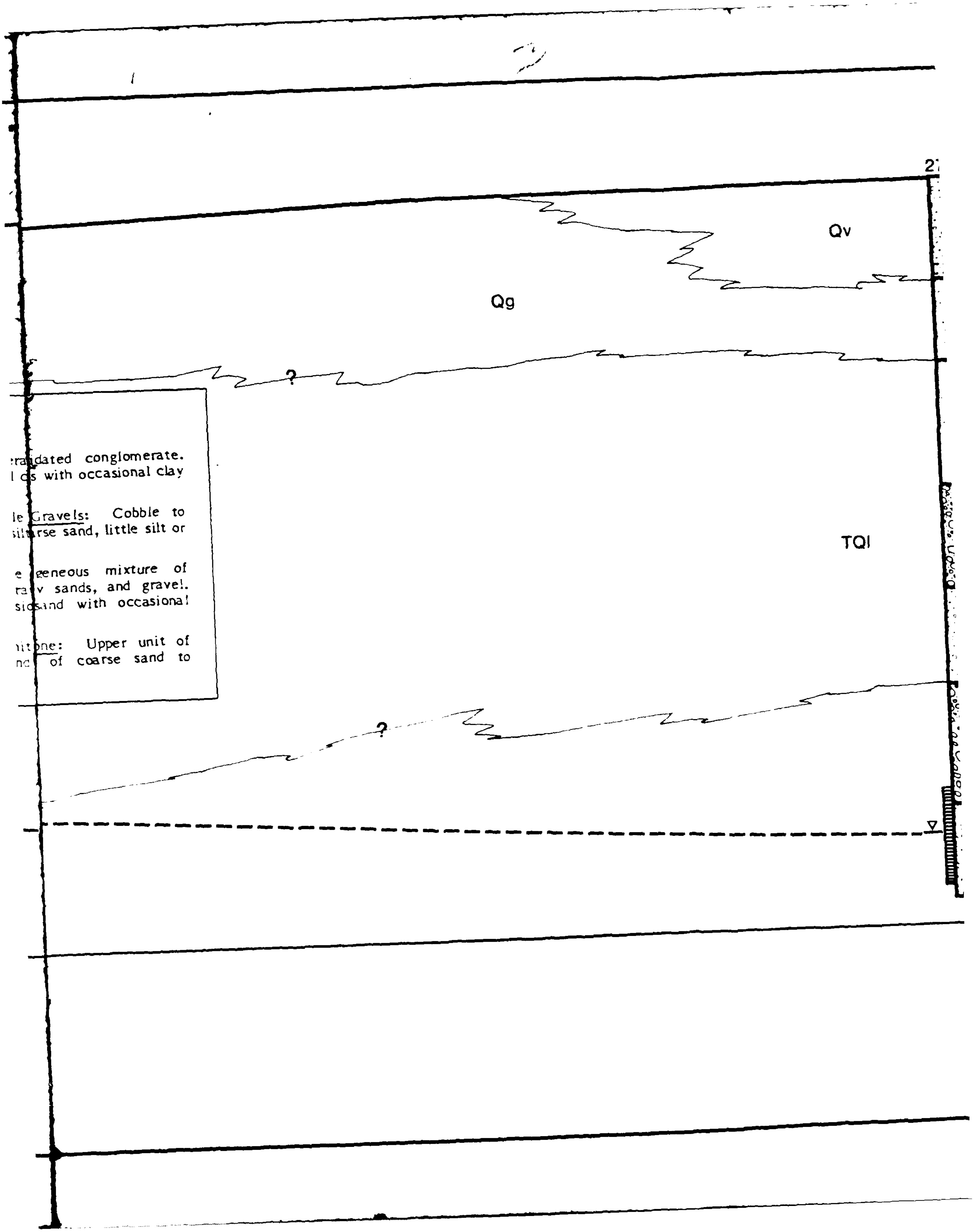
AeroVironment Inc.



NORTH
C
140
120
100
80
60
40
20
MSL
A–A'
21
19
23
22
Qv
Qg
TQl
Ptm
RE



1
Qg
LEGEND
40'
Scale
Vertical
20'
0
400'
800'
1200'
Horizontal
Qv - Victor Formation: Unconsolidated cong
Generally silty sands and gravels with occas
or gravelly clay zones.
Qg - South Fork or Arroyo-Seco Gravels: (
gravel, with medium to very coarse sand, li
clay.
TQl - Laguna Formation: Heterogeneous m
interbedded sands, clay, clayey sands, ar
Matrix material is clay to sand with (
cementation.
Ptm - Laguna-Mehrten Transition Zone: Uppe
Mehrten Formation composed of coarse
cobbles.
NA
REGIONAL WATER TABLE



27
Qv
Qg
?
TQl
?
:ratidated conglomerate.
l cts with occasional clay
le Gravels: Cobble to
silt rse sand, little silt or
e geneous mixture of
ra v sands, and gravel.
sic sand with occasional
nit one: Upper unit of
nc of coarse sand to

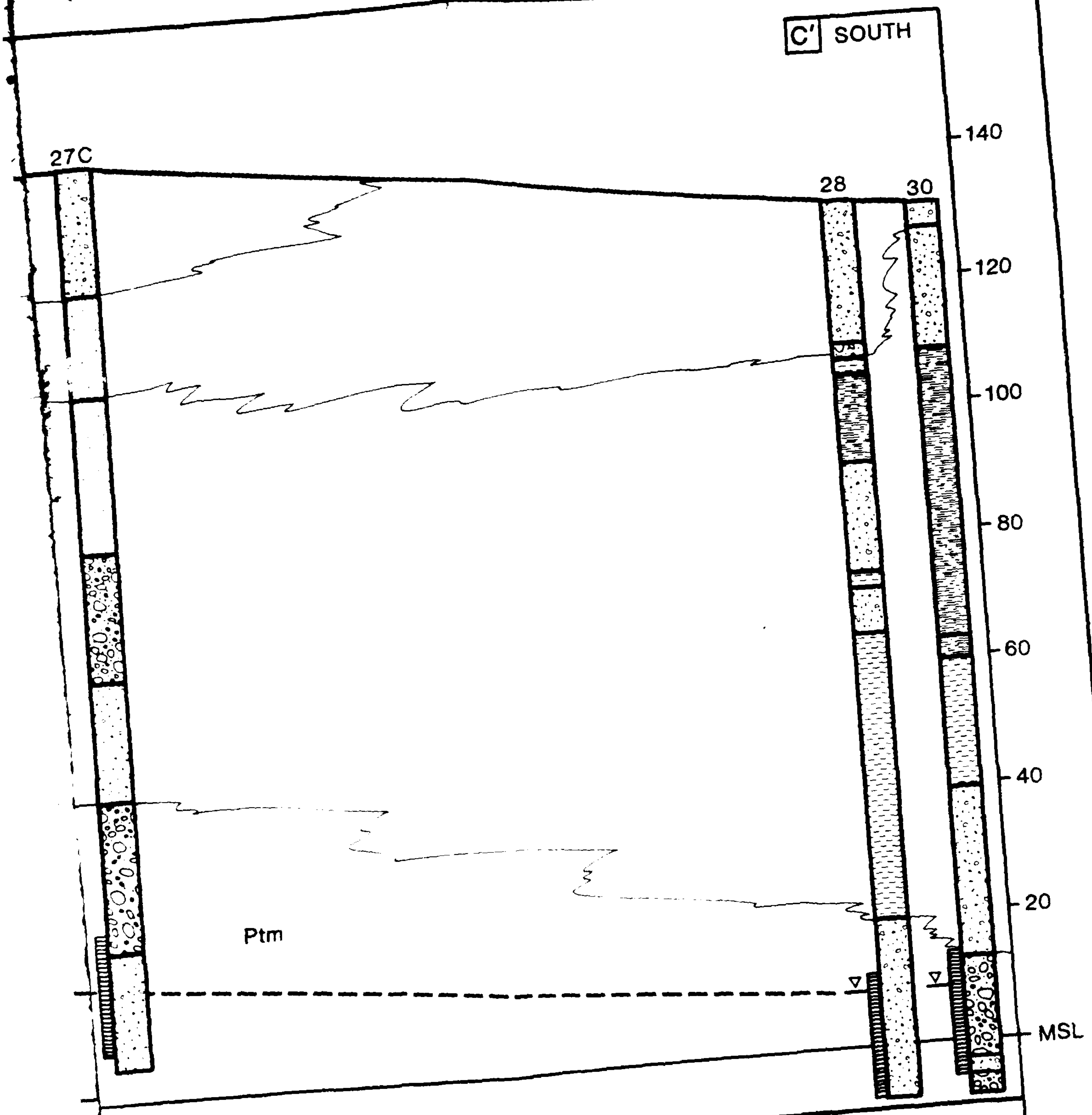


Figure IV-4

Geologic Section C-C'
Mather Air Force Base

AeroVironment Inc.

percolation of surface water in some areas. Little silt or clay is found in this unit. These gravels are ubiquitous at Mather AFB.

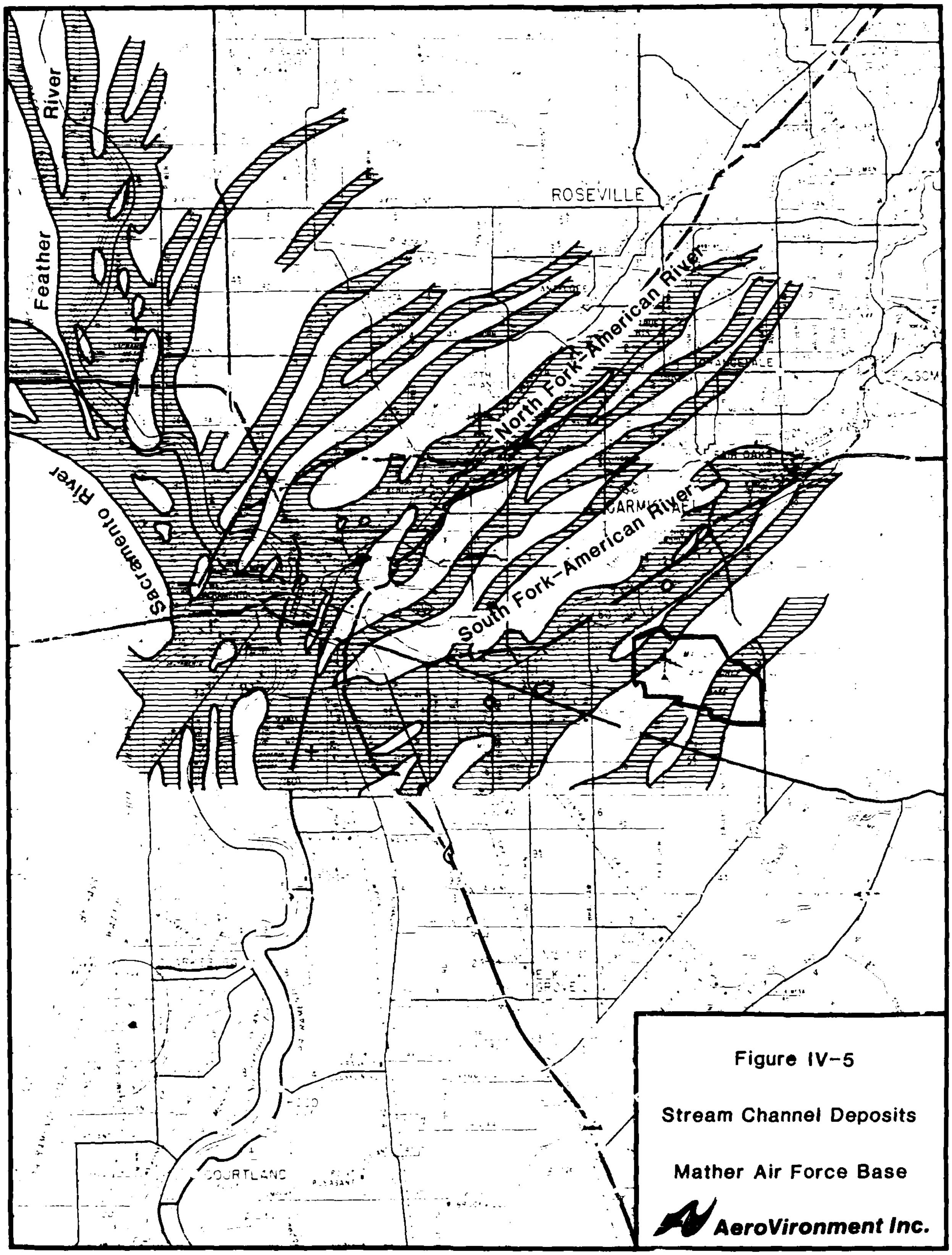
In addition to the South Fork and Arroyo Seco gravels, which are generally a planar deposit in the area directly beneath the base, a major set of buried stream channels known as "the superjacent stream channel deposits" run northeast to southwest beneath the base in two distinct areas. One area is in the northwest corner, and the other is through the east-center of the base. Figure IV-5 shows these deposits. The superjacent stream channel deposits are reported to be 40-60 feet thick, and are generally found at the depth of the water table. Another set of deposits known as "the subjacent stream channel deposits" has been reported to be found below this set, and may represent a portion of the confined aquifer system under the base.

The South Fork/Arroyo Seco gravels lie directly above the Laguna Formation (TQl). The Laguna is a heteorogeneous mixture of interbedded clays, clayey sands, and gravels. The matrix material is clay to silty sand with occasional cementation. Gravel is in small stringers.

Beneath the Laguna Formation, we found a locally continuous unit which is known as the Laguna-Mehrten Transition Zone (Ptm). It has been mapped as either the bottom of the Laguna or the top of the Mehrten. In either case, it is a very coarse sand-to-gravel section with little or no silt. The transition zone was encountered in all AV wells that extended through the Laguna Formation; and it has been reported to have been found during drilling at the Aerojet General Corporation property to the Northeast (CVRWQCB, 1980). In other areas of the basin, the transition zone is not found and the Laguna lies directly over the Mehrten Formation.

2. Groundwater

During the field program at Mather AFB, AeroVironment installed 28 groundwater monitoring wells. These were screened in the first water-bearing zone encountered. After all the wells were completed, measuring points were



87-116

Approximate Scale: 1" equals 4 miles

June 1986

Reference: CH2M Hill, Phase 1, IRP Report 1984.

surveyed to an accuracy of ±0.01 feet above mean sea level (MSL) by a California licensed land surveyor. Lateral location was determined to an accuracy of ±1.0 feet using California state plane coordinates. This information is presented as Table O-1 (Appendix O).

Once the measuring points were established, accurate static water levels were taken and a groundwater contour map was generated. Water levels were also taken from the 11 wells installed during the Phase II, Stage 1 IRP effort, and were incorporated into our map to provide more complete data on groundwater conditions at the base.

We found that the water table aquifer generally flows from the northeast to the southwest, approximately paralleling the runways on base. The elevation of the top of the water table ranges from 65 feet above MSL at the eastern boundary of the base to 2 feet above MSL in the southwest corner. Static water levels are presented in Table O-2 (Appendix O). Groundwater level information, based on measurements of Stage 2 monitoring wells, is presented as Figure IV-6. Contours outside the immediate area of measured wells has been interpolated based on regional flow lines and measured levels.

Two areas of perched groundwater were identified during this study. One area was in the northeast corner of the base near Site 4, and a second area was found in the southwest corner near Sites 2 and 11. Both of these are discussed in greater detail in section 4.B.2. They are shown on Figure IV-6.

The first water found at MAFB-32 and 33 was under confined or semi-confined conditions. Water levels in these wells were not considered to be water table in the strict sense, but merely a piezometric surface. This condition occurred near the northwest edge of the base, but was not encountered in any other area of the base.

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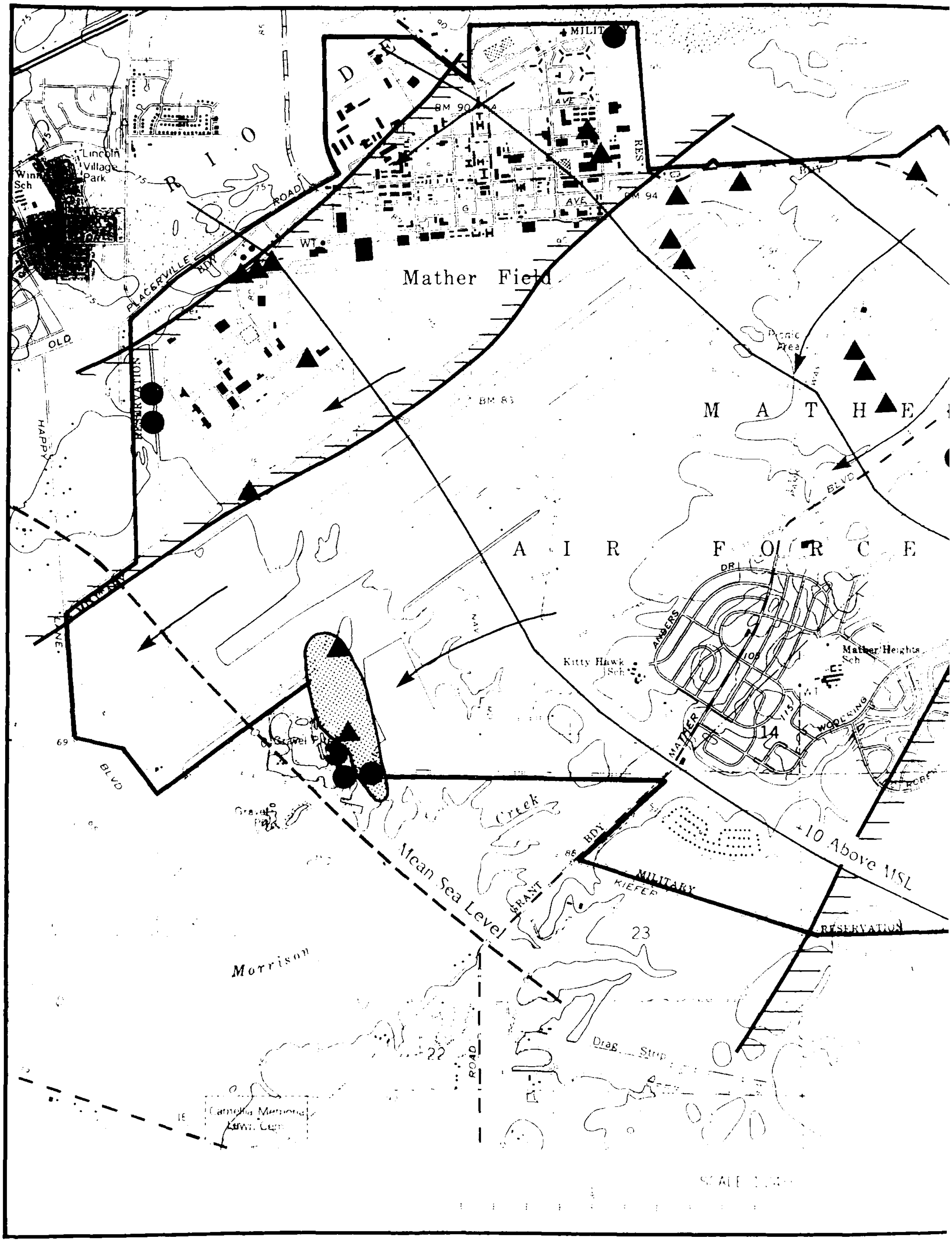
Mather Field
RIO DE
M A T H E
A I R F O R C E
Lincoln Village Park
Winn Sch
PLACERVILLE RD
OLD
HAPPY
RESERVATION
BM 90
BM 94
BM 83
AVE
MILITARY
Picnic Area
BLVD
Kitty Hawk Sch
Mather Heights Sch
ANDERS
MATHER
14
Gravel Pit
Creek
Mean Sea Level
+10 Above MSL
MILITARY
KIEFER
RESERVATION
GRANT
BDY
23
Morrison
22
ROAD
Drag Strip
Camellia Memorial Lawn Cem
69

86-63

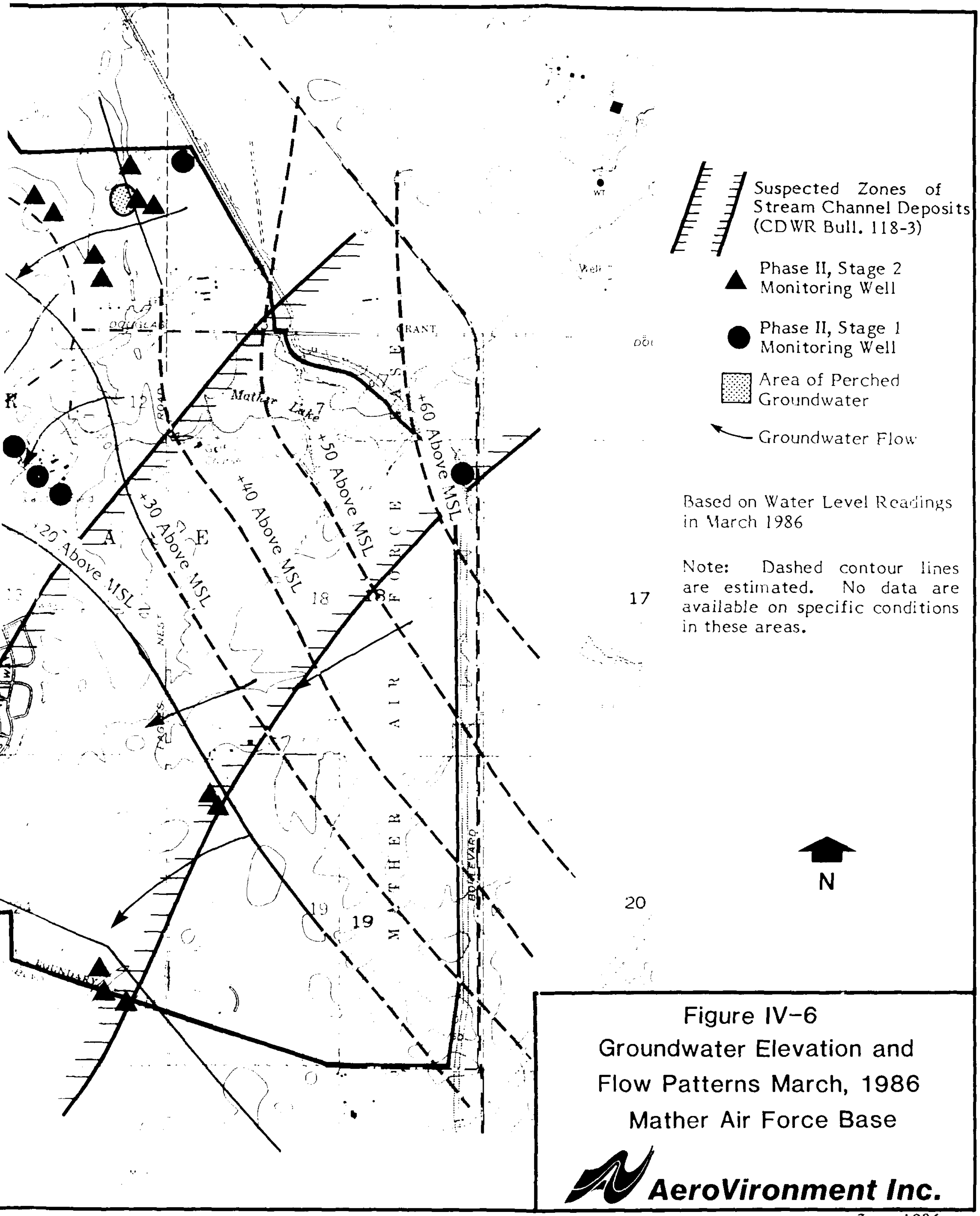

Figure IV-6
Groundwater Elevation and Flow Patterns March, 1986
Mather Air Force Base

AeroVironment Inc.

June 1986

3. Geophysical Data

Eight sites were scheduled to be investigated using both ground penetrating radar (GPR) and terrain conductivity methods. However, the GPR was not used at one of these, Site 19 (fuel tank sludge burial site located within the bulk fuel storage facility), for safety reasons. The graphic recorder sparks during normal operation and this was thought to represent a fire hazard. The remaining seven sites were tested using both GPR and terrain conductivity methods.

The geophysical survey program was very useful in identifying the actual, rather than the assumed boundaries of our sites, as well as in determining the presence or absence of shallow (up to 15 feet below ground surface) plumes.

Site-by-site results may be found in Appendix J. Results of the geophysical surveys pertinent to locating the monitoring wells are briefly described below. Figures showing the geophysical anomalies mapped at the eight sites appear in Appendix J. At all eight of the sites studied, monitoring wells were drilled downgradient from the site's edges, as identified from the geophysical survey.

Site 1 -- Runway Overrun Landfill

Three trenches and a small pit were identified. These features do not contain an appreciable amount of metal objects or ionic compounds and there are no obvious contaminant plumes associated with them.

Site 3 -- N.E. Perimeter Landfill No. 1

The NE and NW areas are highly conductive and contain many small trenches (oriented N-S) with surface depressions. The surface and subsurface contains a multitude of metal objects. The surface depression on the east edge is also highly conductive. A contaminant plume may extend south of this pond under the drainage ditch.

Site 4 -- N.E. Perimeter Landfill No. 2

Three quarters of the landfill (except the NW corner) is highly conductive with many N-S oriented trenches filled with metal objects. The landfill is contained within the topographic rise. There is no evidence of a plume traveling SW from the site.

Site 5 -- N.E. Perimeter Landfill No. 3

A long, shallow trench (oriented E-W) parallels the dirt road in the southern part of the site. The trench contains many metal objects and extends south at least to the RV storage fence. No plume from the trench is obvious, but the area to the south could not be surveyed because of interference from the metal fence.

Site 8 -- Fire Department Training Area No. 1

A small, conductive zone in the NE corner of the site could indicate either a landfill or a fire training area. Radar does not show buried metal objects or a trench, which would indicate a landfill, so this may be a fire training area. We found no evidence of a plume.

Site 10 -- Fire Department Training Area No. 3

A high conductivity zone oriented N-S was discovered along the west edge of the site. The area shows no evidence of trenches, and thus of landfills, and only a few pipelines along the south edge. This indicates an absence of structures near the conductivity zone in the past. Historic air photos have shown that the fire training area was not at this site as originally thought, but the site was investigated further due to the discovery of the high-conductivity zone.

Site 19 -- Fuel Tank Sludge Burial Site

There is a small, low-conductivity zone just NW of the warning sign and a high-conductivity zone to the SW.

Site 20 -- MOGAS Spill Site

The MOGAS storage tank was located adjacent to the SW corner of the concrete foundation of building 7125. It was very difficult to interpret the geophysical data at this site due to the numerous buried pipes associated with the sewage treatment plant in the area.

4. Soil Sampling Results

Soil samples were collected at two sites, Site 19 (Fuel Tank Sludge Burial Pit) and Site 10A (FPTA No. 3). Laboratory results are presented in Tables N-1 and N-2 (Appendix N). These results indicate that there is no contamination in the soil at either site.

All of the samples showed trace concentrations of methylene chloride, but this is believed to be a result of laboratory contamination. Other organic compounds were reported for some of the samples in concentrations of approximately 1 ppb or less. Because of the very low levels, these compounds are considered to be field error or laboratory "noise." Oil and grease concentrations were less than 100 ppm in all samples.

5. Water Sampling Results

Groundwater samples were collected in two rounds from each of the 28 wells installed during the Phase II, Stage 2 project. The first round of samples was collected in December 1985, the second in January 1986. Some wells were resampled in March 1986 because some of the original samples were not analyzed within the holding time. The laboratory results of the two acceptable sets of groundwater samples are summarized in Tables N-3 through N-30 (Appendix N).

Samples collected for volatile organic analyses (VOA) Method 602 in December and DBCP in January were not analyzed by the laboratory within the specified holding time. The affected wells were resampled in March 1986 and August 1986. Tables N-3 through N-30 present the resampling results, in place of the original analysis which was not completed.

The two sets of analyses for each well provide an opportunity to check that the results are reproducible. The samples were taken about 30 days apart, so no time-induced changes are expected. In general, the analytical results from the two sampling rounds agree very well. Quality assurance data are presented along with the actual laboratory reports in Appendix G. Quality assurance/quality control results for the water samples are discussed in detail in Appendix M.

Two sections of Mather AFB appear to have contaminated groundwater (in addition to areas identified in Phase II, Stage 1). These are the northeast corner and the northwest corner of the base. AV wells in the northeast corner of the base showed four chemicals above their level of quantification: trichloroethylene (TCE), tetrachloroethene (PCE), trans-1,2-dichloroethene (DCE) and 1,2-dichloropropane. AV wells in the northwest corner showed TCE contamination only. AV wells in the central and southern parts of the base showed no sign of contamination.

For this investigation, the criteria for establishing the significance of analytical findings must take into account the following factors:

- Laboratory or field-induced background contamination, identified using laboratory and field blank samples.

- The level of quantification (LOQ) for the analyte of interest, which is typically calculated as five to ten times the method's detection limit.

- The reproducibility of the measurements, both within sampling rounds and between rounds.

- The DOHS action levels for applicable parameters. Parameters for which action levels are not specified are assessed using other accepted water quality standards and available toxicity data.

In determining whether a finding is significant, after the data have been reviewed for validity (laboratory and field Quality Assurance/Quality Control evaluation), the first step is to determine whether a DOHS action level has been established for the parameter. Current DOHS action levels are presented in Table IV-1. In some cases, the action level is below the LOQ for a given parameter. In these cases, the detected concentration must be considered significant, assuming all necessary QA/QC objectives have been met. Results which were not repeatable between rounds but indicated an exceedance of a DOHS action level for one sampling round must also be considered significant, though inconclusive.

Almost all of the groundwater samples showed small amounts of methylene chloride (including the field blank). This is considered laboratory-induced contamination. Table IV-2 summarizes the results of field blank analyses. Chemicals found in samples were compared to chemicals found in the blank. If a chemical is found in a sample at a concentration at or lower than the concentration found in the blank, it is considered either laboratory- or field-induced error. In addition, other compounds were reported at low concentrations on some samples, but were below the quantification level and usually not repeatable. Results which are not above the level of quantification of the method (typically 5-10 times detection limits) are not precise and are not considered significant. Results which were not repeatable, that is, which did not occur in both sampling rounds, are generally not considered significant unless a DOHS action level is exceeded.

Toluene was found in many of samples, particularly those which were resampled in March. This was found to be a field contaminant resulting from

TABLE IV-1. Action Levels Recommended by the California Department of Health Services, December 1986

Chemical		Action Level parts per billion (ppb)
Pesticides		
Chlorinated Hydrocarbon		
Aldrin		Limit of Quantification (0.05)
a-Benzene Hexachloride (a-BHC)		0.70
b-Benzene Hexachloride (b-BHC)		0.30
Chlordane		0.055
Dieldrin		Limit of Quantification (0.05)
Heptachlor		0.02
Heptachlor Epoxide		0.10
Pentachlorophenol		30.00
Organophosphate		
Dimethoate		140.00
Diazinon		14.00
Ethion		35.00
Malathion		160.00
Methyl Parathion		30.00
Parathion		30.00
Trithion		7.00
Carbamate		
Aldicarb		10.00
Baygon		90.00
Carbaryl		60.00
Phthalamide		
Captan		350.00
Amides		
Diphenamide		40.00
Fumigants		
Dibromochloropropane		1.00
1,2-Dichloropropane	(M)	10.00
Ethylene Dibromide		Limit of Quantification (0.02)
Chloropicrin		50.00 (37.0)*
Miscellaneous		
Terrachlor (Pentachloronitrobenzene)		0.90

*Taste and Odor Threshold
(M) Compound found at Mather AFB

TABLE IV-1. (con't)

Chemical		Action Level parts per billion (ppb)
Herbicides		
CIPC		350.0
(isopropyl N (3-chlorophenyl carbamate)		
Bolero		10.0 (Tentative)
(thiobencarb)		1.0*
Ordram		20.0
(Molinate)		
Glyphosate		500.0
Atrazine		15.0
Simazine		150.0
Bentazon		8.0
(Basagran)		
Purgeable Halocarbons		
Carbon Tetrachloride		5.00
1,2-Dichloroethane		1.00
1,1-Dichloroethylene		6.00
Methylene Chloride		40.00
Tetrachloroethylene	(M)	4.00
1,1,1-Trichloroethane		200.00
Trichloroethylene	(M)	5.00
Vinyl Chloride		2.00
Cis-1,2-Dichloroethylene		16.00
Trans-1,2-Dichloroethylene	(M)	16.00
1,1-Dichloroethane		20.00
1,1,2-Trichloroethane		100.00
Freon 11		3400.00
Freon 13		18,000.00
(Action Level for Cis and Trans 1,2-Dichloroethylene is either for a single isomer or for the sum of the 2 isomers)		
Purgeable Aromatics		
Benzene		0.70
Monochlorobenzene		30.00 (3)*
1,2-Dichlorobenzene		130.00 (10)*
1,3-Dichlorobenzene		130.00 (20)*
1,4-Dichlorobenzene		Limit of Quantification (0.5)
Ethylbenzene		680.00 (29)*
(Action Level for dichlorobenzene is either for a single isomer or for the sum of the 3 isomers)		

*Taste and Odor Threshold
(M) Compound found at Mather AFB

TABLE IV-1. (con't)

Chemical	Action Level parts per billion (ppb)
Toluene	100.00
Ortho-Xylene	620.00
Para-Xylene	620.00
Meta-Xylene	620.00
(Action Level for Xylene is either for a single isomer or the sum of the 3 isomers)	
Phenols	
2,4-dimethylphenol	400.00*
Phenol	1.00* (for chlorinated systems)
Aldehydes	
Formaldehyde	30.00

*Taste and Odor Threshold

TABLE IV-2. Summary of Field Blank Contamination.

Chemical	Maximum Concentration Found in Blank (μg/l)
Methylene Chloride	3.1
Chloroform	1.2
1,1,1-TCA	0.45
TCE	0.5
Benzene	0.4
Toluene	0.7
Ethylbenzene	0.9
Chlorobenzene	0.3

the use of a particular brand of electrical tape in the sampling process. Electrical tape was used every 10 feet to secure the wiring for the submersible pump to the discharge line while the pump was in the hole. The tape was placed so that it did not rest in the water, but during the pump removal, some water from the discharge line cascaded down the remaining pipe in the hole. A VOA blank was submitted to the lab with a piece of electrical tape in it, to check for possible contamination from this tape/water contact. A VOA sample prepared with blank water and the tape used in the December and January sampling rounds (K-Mart brand tape) showed a toluene concentration of about 22 ppb. The "tape" blank submitted with the March sampling (Sears brand) had a toluene concentration of 2500 ppb. In addition, the highest concentration of toluene in a sample was found in MAFB-22, where the pump had been rewired because of mechanical problems. The Sears tape was used to help repair the pump just prior to pumping MAFB-22. As a result, all toluene results are considered to be field-induced contamination.

All wells also showed detectable levels of oil and grease, typically ranging from 0.5 ppm to 3 ppm. Wells in the southern part of the base, which are otherwise considered clean, showed levels up to 3 ppm. As a result, with one exception, the oil and grease concentrations are not considered significant. The exception is MAFB-19, which had an oil and grease concentration of 6.3/9.8 mg/l (1st round/2nd round) and also a significant concentration of PCE.

A total of 40 "significant" results were identified in the ground-water volatile organics' data package. They are shown in Table IV-3. PCE and TCE were found in 12 wells each, trans-1,2-dichloroethene (trans-1,2-DCE) was found in 11 wells, and 1,2-dichloropropane was found in 5 wells. Eleven of the wells sampled in this project contained volatile organic compounds in excess of California Department of Health Services (DOHS) action levels for water. Table IV-1 lists the current state action levels. Two wells (MAFB-31 and 33) located in the northwest corner exceeded the level for TCE. Eight wells (MAFB-19, 20, 12, 24, 25, 26, 14, and 15) located in the northeast corner exceed the level for PCE, and one well (MAFB-21), in the same area, exceeded the standard for PCE and trans-1,2-DCE.

TABLE IV-3. Summary of Significant Results.

Well No.	Compound	1st Round Result/ 2nd Round Result
12	DCE	8.6/9.8
	TCE	1.3/1.3
	PCE	8.2/8.4*
	Dichloropropane	.54/.41
13	DCE	0.7/1.2
	TCE	1.6/2.0
	PCE	0.9/1.1
14	DCE	6.5/7.3
	TCE	2.4/2.4
	PCE	ND**/5.7*
	Dichloropropane	.29/.23
15	DCE	8.3/11
	TCE	1.5/1.5
	PCE	8.9/9.7*
	Dichloropropane	.32/.24
16-18	None	
19	DCE	10/12
	TCE	2.4/2.8
	PCE	22/25*
20	DCE	0.7/1.1
	PCE	3.3/4.7*
21	DCE	23/32/35*
	TCE	2.6/3.7/4.5
	PCE	24/31/35*
22	None	
23	DCE	0.6/0.9
	PCE	1.2/1.3
	Dichloropropane	ND/6.1
24	DCE	3.9/4.5
	PCE	4.8/5.2*

TABLE IV-3. (cont'd)

Well No.	Compound	1st Round Result/ 2nd Round Result
25	DCE	5.6/5.6
	TCE	1.0/0.7
	PCE	10/11*
26	DCE	12/11
	TCE	1.9/1.4
	PCE	12/10*
	Dichloropropane	2.1/1.6
27-30	None	
31	TCE	24/23*
32	None	
33	TCE	67/55*
	PCE	2.1/1.4
34-35	None	
36	TCE	ND**/2.6
37	TCE	1.5/1.4
38-39	None	

*Exceeds California Department of Health Services Action Levels
**Initially detected by GC techniques but not confirmed by GC/MS

All results are μg/l
DCE: trans-1,2-Dichloroethene
PCE: tetrachloroethene (perchloroethene)
TCE: trichloroethene

None of the wells showed any elevated levels of lead, nitrate, sulfate or chloride. The anions sulfate, nitrate and especially chloride were higher in well MAFB 16, 26 and 27, but were below drinking water standards in all of the wells. EDB and DBCP were not detected in any of the samples.

No background, or upgradient wells were installed or sampled as part of this Phase II, Stage 2 effort. As a result, no immediate comparison can be made between upgradient and downgradient conditions. This will be discussed further in the next section.

6. Analytical Summary

AeroVironment has been able to confirm the presence of volatile organic groundwater contamination in two areas of the base. They are:

- o Northeast corner of the base -- Sites 1, 3, 4, 5, 8, 13 and 23
- o Northwest corner of the base -- Sites 10A/B, 14, 18 and 19

Because of the close proximity of the sites in these areas, it is difficult to assess which of the sites are contributing to the problems. Well samples collected in the central and southern portions of the base show no sign of degradation. The sites in these areas are Nos. 2, 6, 11, 17, and 20. The contaminants identified in the groundwater are trichloroethene (TCE), tetrachloroethene (PCE), trans-1,2-dichloroethene (DCE) and, at lesser concentrations, 1,2-dichloropropane. The first three are solvents which are commonly used as degreasing agents. 1,2-dichloropropane is both a degreaser and a fumigant, sometimes used for pest control.

Although AV was able to verify that contamination exists, we could not determine the exact source or the full extent of contaminant movement. This is because 1) no comparable upgradient groundwater monitoring wells exist, and 2) the only far downgradient wells are located near other sites.

The groundwater sampling results were compared to current action levels obtained from the California Department of Health Services (DOHS). DOHS has established the action levels for many volatile organic compounds on the Methods 601/602 analysis list, including the four identified in the Mather AFB samples (see Table IV-3). Some of the parameters AV tested for have no DOHS action levels. The following criteria were used on those parameters:

Lead: 50 µg/l, U.S. EPA drinking water standards
Chloride: 250 mg/l, U.S. EPA drinking water standards
Sulfate: 250 mg/l, U.S. EPA drinking water standards
Nitrate: 45 mg/l, U.S. EPA drinking water standards

No standards exist for EDB, DBCP, or oil and grease; however, neither EDB nor DBCP were detected in any samples. Oil and grease was detected in all of the samples. The EPA publication, "Quality Criteria for Water" (U.S. EPA, 1975), recommends that water be "...virtually free from oil and grease." However, no numerical criteria are listed for humans. Oil and grease results from Mather AFB are all approximately the same, with the exception of one well. As a result, we have assumed that the levels in otherw... clean wells are background, and all other wells with similar concentrations are also background.

Soil samples collected at Mather AFB showed no sign of contamination.

B. Significance of Findings

1. Possible Contamination Pathways

A number of geologic factors affect the migration of contaminants from the surface or shallow subsurface into the water table.

The first, and most obvious is that the base has relatively low topographical relief, and therefore runoff rates are low. This allows rain water, and potential spills, to be retained for longer periods in one area, giving time for

percolation to occur. Most of the upper soils are relatively permeable, but there is a well-defined hardpan zone under many areas of the base that will inhibit downward migration. In those areas where the hardpan layer has been breached (landfill trenches, etc.) or does not exist, infiltration to the underlying strata may be fairly high.

The production zone for most wells on base begins at approximately 100 to 150 feet below the ground surface. The strata above the production zone generally consist of alternating layers of sand, gravel, silt and clay of varying permeability. The rate of percolation to the production zone is relatively higher in those areas where the overlying beds are predominantly gravel or sand and silt, rather than clay.

In the vicinity of production wells, the drawdown caused by a pumped well results in the highest head differential between the upper strata (possible source of contamination) and the production zone. Therefore, the driving force for contaminant movement between the upper strata and the production zone is highest in the vicinity of the production wells. A number of pathways for contamination occurring in the upper strata to enter the production zone are possible. The primary pathways are shown in Figure IV-7. The first is infiltration and leakage from the upper strata into the production zone through the confining layer. The source of the leakage is at an upgradient location. This is especially critical where the overlying strata are permeable due to gravel near the surface. A contributing factor to this pathway of pollutant travel into production wells is the placement of well screening in relatively shallow, permeable zones. In some of the production wells, perforation begins as shallow as 45 feet. This upper or first permeable zone would be the first stratum to be contaminated, and wells which tap these shallower zones in areas where contamination exists are likely to become contaminated.

A second contamination pathway is the vertical movement of pollutants from a contaminated shallow aquifer, down the annular space of a well and into lower aquifers. This is a common source of pollution in old wells and is related to past well construction practices where no seal or an inadequate seal was

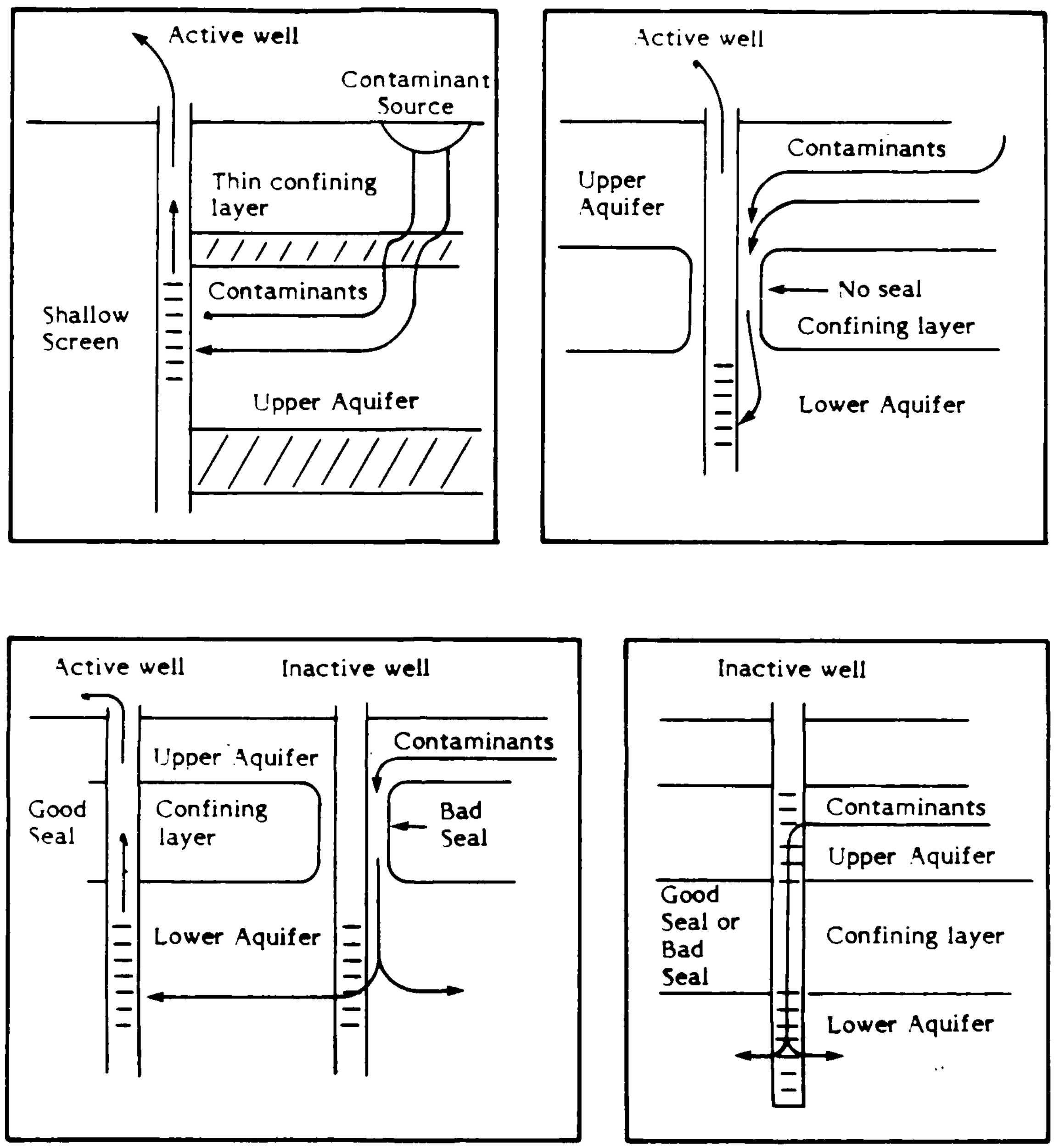

Figure IV-7

Possible Contamination Routes

Mather Air Force Base

AeroVironment Inc.

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provided between surface zones and deeper zones from which water is drawn into the well. This situation can cause problems in two ways. If the well is active, the contaminants will be drawn down through the well's gravel pack and be pumped up into the water supply. If the well is abandoned or not currently pumping, contaminants can flow down the gravel pack and begin to disperse into the previously "clean" aquifer. This newly contaminated aquifer water may be pumped into water supplies from the "source well" or another deep well downgradient. Another way for contaminants to spread to lower aquifers is through inactive wells which have screens in two or more aquifers. In this scenario, water enters the upper screen, flows down the inside of the well and exits a deeper screen into the aquifer.

One of the most significant geologic features affecting contaminant migration in a horizontal direction is the old buried stream channels of the American River. Figure IV-5 illustrates the most prominent series of these channels in the Mather AFB area. This figure illustrates what is referred to as the "superjacent stream channel deposits." These deposits are generally quite permeable (approximately 30 ft/day), as much as an order of magnitude higher than the surrounding sediments. Furthermore, the channel deposits are oriented in a soutnwest-northeast direction parallel to the regional flow of groundwater at Mather AFB. This fact is important because there are potential contamination sources located upgradient from Mather AFB and these stream channels could contribute to movement from the potential sources.

Other factors affect vertical migration potential in the vicinity of the base. Surrounding Mather AFB to the north, northwest, and west is an area covered by gold mining dredge tailings. This operation consisted of mining by dredging the upper 20 to 30 feet of sediment and redepositing the gravel and cobbles as mining tailings. Due to the dredging, any hardpan layer that may have been present was destroyed and the permeability of the dredge tailings is quite high.

The major set of stream channel deposits mentioned earlier is only one of many such sets deposited as the American River meandered across the

valley floor. As the stream continued to deposit fine grained material on the flood plain and carried coarse materials as stream bed load, a series of high permeable zones (buried stream channels) and low permeable zones (flood plains) built up on top of one another. In some areas, a buried stream channel may be isolated both above and below by the occurrence of fine grained materials from preceding and anteceding flood plains. Thus, a contaminant reaching the uppermost buried stream channel would have to take a tortuous path before reaching the next set of channels. In many areas, however, each succeeding stream channel is overlain and hydraulically connected to the next stream channel due to its high permeability, thus greatly increasing the rate of vertical movement. The South Fork and Arroyo Seco gravels, which are found underlying many areas of the base, were deposited in this manner. As such, they do little to retard fluid flow from the surface down to the top of the Laguna Formation, or to perched water where it exists. The water table aquifer on base is found in either the Laguna Formation or in the transition zone between the Laguna and underlying Mehrten Formation. Water percolates slowly through the Laguna Formation, which has much more clay and silt than the overlying gravels. Contaminants travelling slowly through the Laguna Formation would quite likely sorb onto clay or silt particles, which would inhibit passage into the groundwater.

2. Site Specific Descriptions

Due to the close proximity of many of the sites and the associated similarities of geology and possible contamination pathways, the sites will be discussed using the same groupings that were used in the site-specific geology section in Chapter II.

Area I

Site 2 - "8150" Area Landfill

Three wells were installed downgradient from the "8150" landfill (see Figure IV-8) and no contaminants were found in any of the wells. The absence of contaminated groundwater at this site is not surprising for a number of reasons:

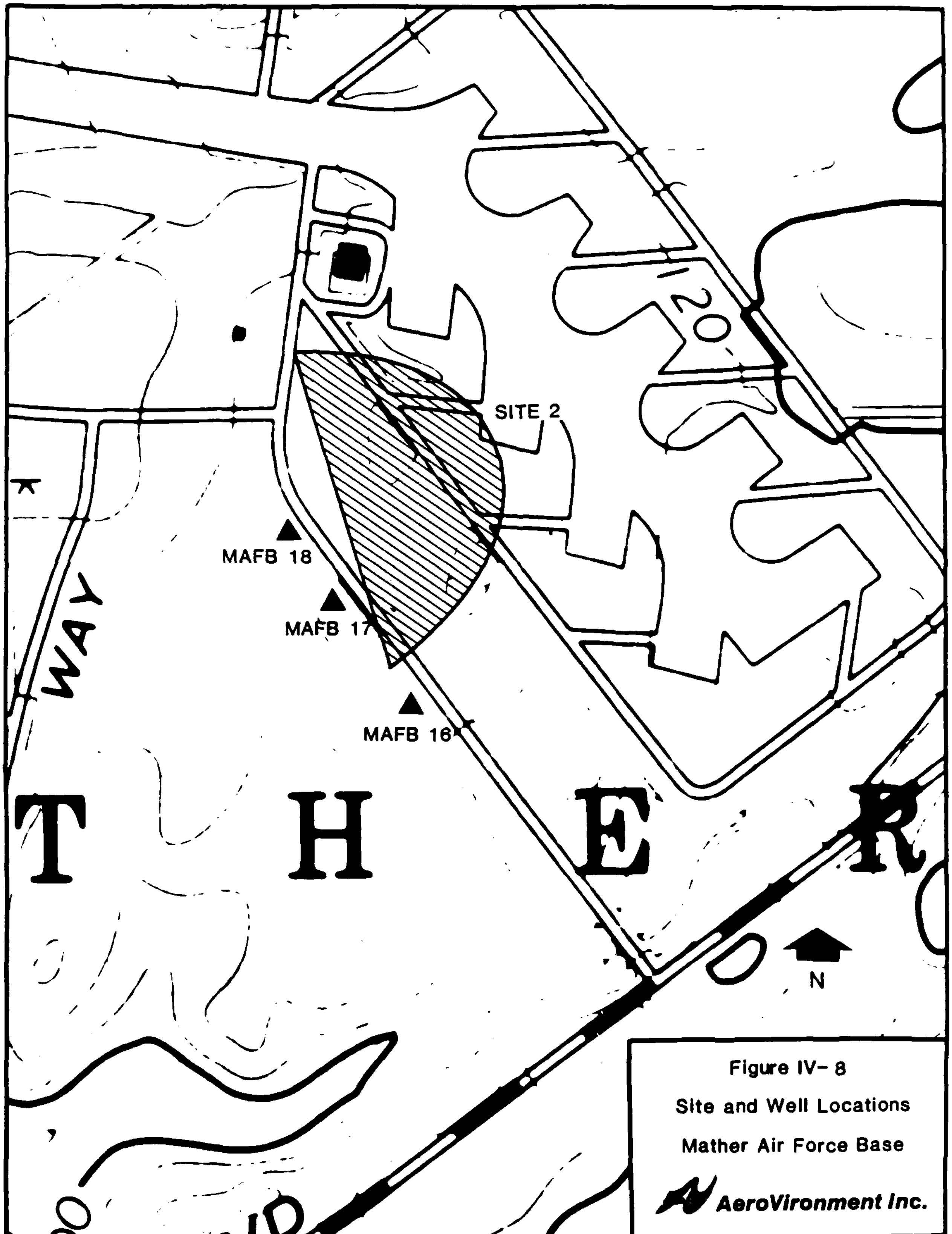

Figure IV- 8
Site and Well Locations
Mather Air Force Base
AeroVironment Inc.
June 1986

Scale: 1" = 400'

Reference: USGS Topo maps and USAF Master Plan for Mather AFB, 30 Sept. 83.

- The site has not been used for trash disposal for 35 years, and is not reported to have received significant amounts of shop wastes.

- Much of the site is currently covered by the SAC alert area. The concrete and buildings covering much of the area limit the rainfall that is able to percolate through the fill material. This removes the hydraulic driving force needed for leachate generation and/or migration off site.

- The site is underlain with a thick section of silt and clay which should provide some protection to the aquifer.

Site 3 - Northeast Perimeter Landfill No. 1

All three wells installed downgradient from Landfill No. 1 (see Figure IV-9) showed levels of PCE in the groundwater that were above DOHS action levels. PCE concentrations ranged from 4.8 to 12 ppb; the DOHS action level is 4 ppb. The wells also showed varying amounts of contamination from TCE, DCE and 1,2-dichloropropane. A near-surface conductive anomaly was found during the geophysical investigation of this site which may represent a plume migrating from the site.

It was reported in the Phase I investigation that large quantities of waste solvents and thinners may have been disposed at this site. It is possible that the solvents found in the water have percolated from the landfill. This theory is supported by the fact that the highest PCE concentrations (12 ppb) are found in well MAFB-26, which has the thinnest section of silt and clay above the water table. MAFB-24, which is nearest to the possible shallow plume, has only 4.8-5.2 ppb of PCE, but also has a 30-foot thick section of silt and clay to protect the water table from direct percolation. However, there is still some question about the source of the PCE and other solvents in the water downgradient from this site because no upgradient wells were sampled to verify the quality of water entering the site from the northeast.

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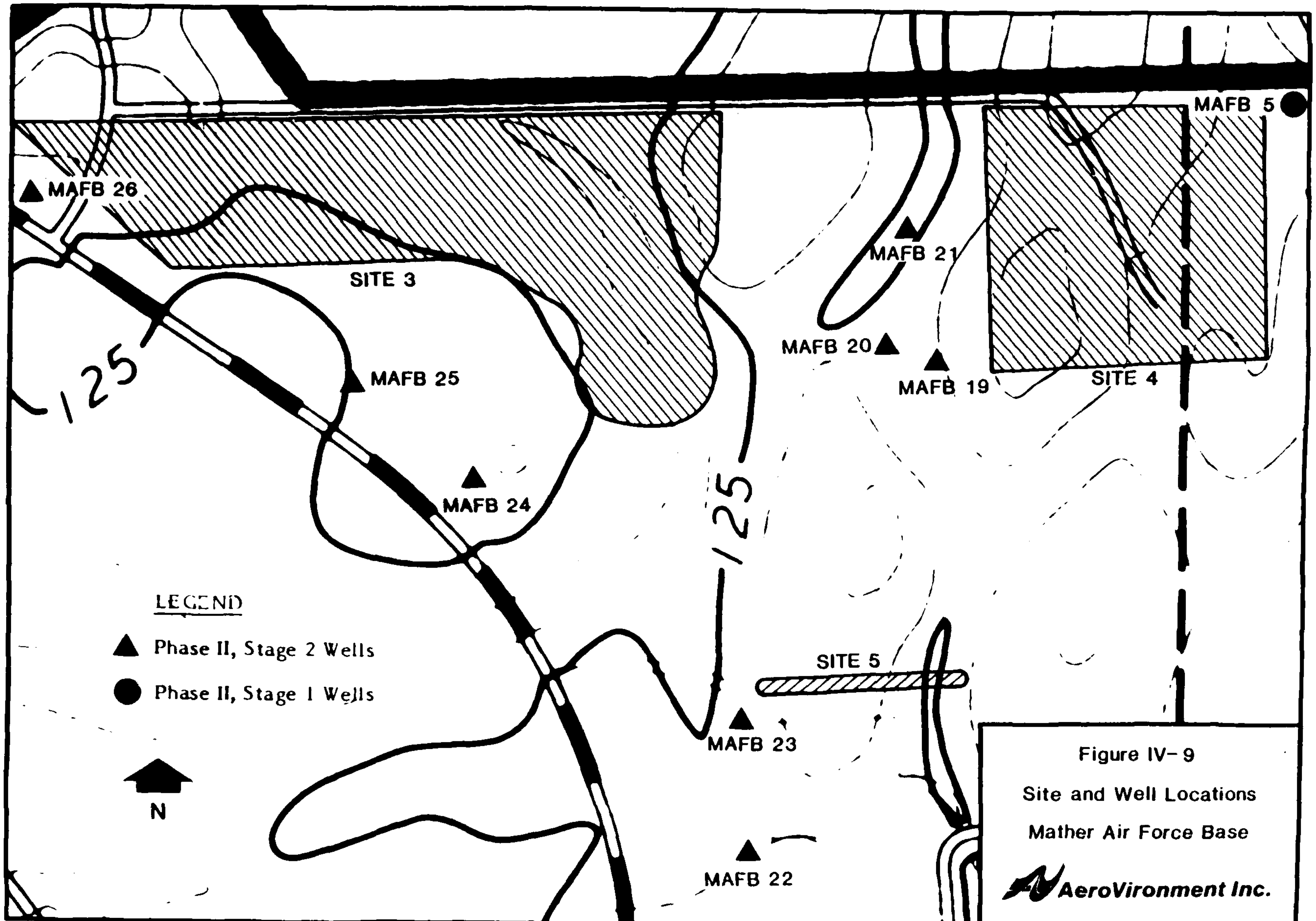


Figure IV-9
Site and Well Locations
Mather Air Force Base
AeroVironment Inc.

Scale: 1" = 400'

June 1986

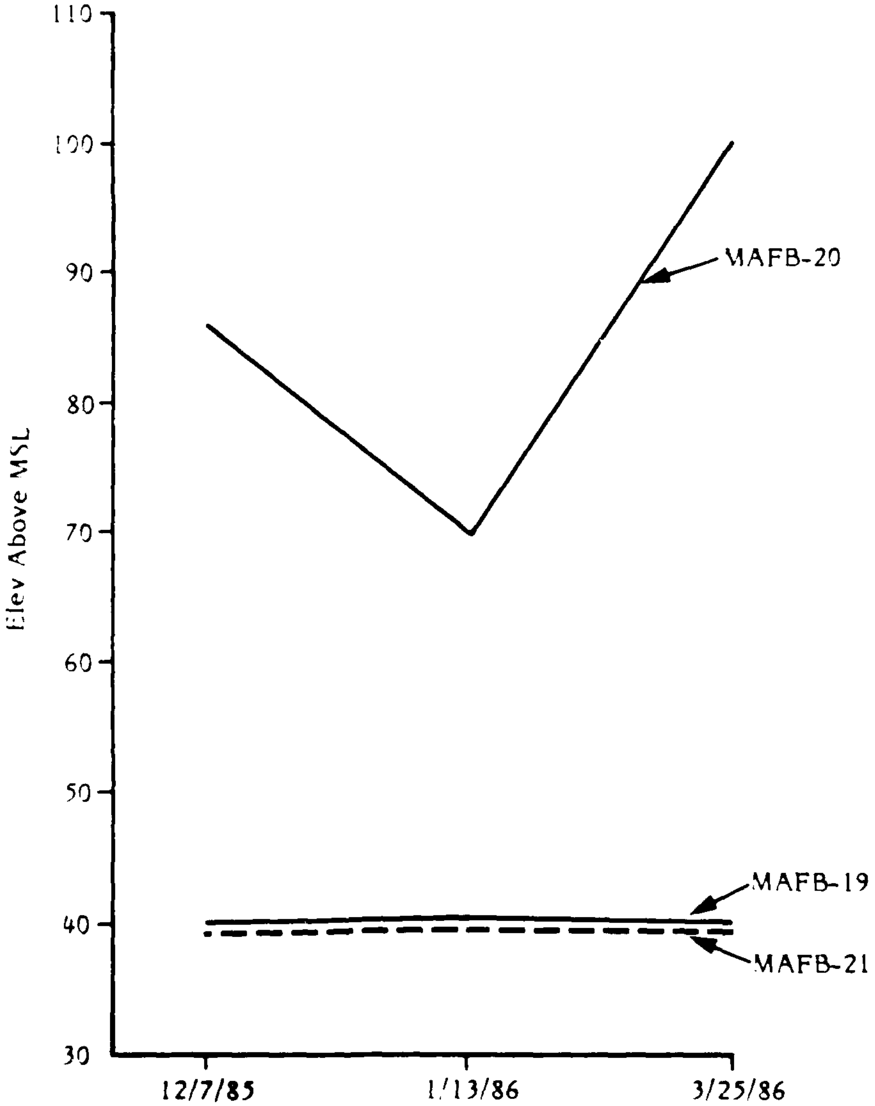
Reference: USGS Topo maps and USAF Master Plan for Mather AFB, 30 Sept. 83

It is known that the water table aquifer has been degraded by the presence of PCE and other organic solvents. However, the probability of further migration into the confined aquifers is rather small. Borings drilled during this study did not extend far into the Mehrten Formation, which supplies most deep wells in the area, but by studying well logs from other drilling we have been able to learn a great deal. Below the Laguna-Mehrten transition zone the predominant lithology is indurated sand stones, silt stones and clays. The confined aquifer is composed of interbedded silt, sand, coarse sand and gravel, and non-indurated clays. The indurated sediments above the aquifer should protect it from the relatively low levels of organics that are found in the water table. There are no nearby wells downgradient of the site which would serve as conduits from the water table to the confined aquifer.

Site 4 - Northest Perimeter Landfill No. 2

Three wells were installed at Site 4 (see Figure IV-9). One of the wells, MAFB-20, appears to have been unintentionally completed in an old stream channel deposit that is not hydraulically connected to the regional water table. Static water level (SWL) readings were taken three times between early December, 1985 and late March, 1986. In MAFB-20, it ranged between 30 and 60 feet above the regional groundwater levels for this area of the base, as defined by MAFB-19 and 21, which are located nearby (see Figure IV-10). We believe that MAFB-20 is completed in a perched water zone that may be fed by water in the gravel pits directly north of the base boundary. Although water levels in the quarry were not measured, the fluctuation in the SWL in MAFB-20 appeared to follow fluctuations in quarry water levels.

Fortuitously, the perched water in this well provided information on hydrologic conditions which were previously unknown. MAFB-20 exceeded the State action level for PCE in one sample round, and was very near it in the other. Since the perched water zone is probably recharged by water in the quarry off base or by direct percolation from the surface, this may indicate that PCE is entering the groundwater system from this site, but it is not conclusive.



Note: MAFB-5 is also located in this area but measurements were not taken as part of stage 2.

86-61

Figure IV-10
Static Water Level in Test Wells
Site 4
Mather Air Force Base

AeroVironment Inc.
June 1986

MAFB-19 and 21, which are also downgradient from Site 4, were screened in the regional water table aquifer. Both of them had high PCE concentrations, up to 35 ppb in MAFB-21, and TCE was found at a level of 4.5 ppb in the same well. The action level for TCE is 5.0 ppb.

During the Phase II, Stage 1 IRP study, an upgradient well (MAFB-5) was installed near the northeast corner of the landfill. This well was not sampled. Unfortunately, it was installed in a manner that is not comparable with downgradient wells installed by AeroVironment. The well screen is set entirely in a clay zone and the top of the well screen is 10-15 feet below the water table surface. AV wells in the area were screened in a gravel and sand zone near the top of the water table. The only way water can enter the MAFB-5 well casing is to percolate down through the gravel pack for seven feet and trickle into the well screen. Because of these problems, the data from MAFB-19 and 21 are unlikely to match the results obtained from MAFB-5. When last sampled in June, 1985, MAFB-5 was found to be essentially clean, with only a trace of PCE and no TCE detected. While this seems to indicate that the PCE found in MAFB-19 and 21 is a direct result of dumping at Site 4, it would be wise to drill compatible upgradient well(s) before drawing final conclusions about northeast corner problems.

Whatever the source, we know the water table downgradient from Site 4 has been contaminated by PCE and other solvents. The potential for contamination of the confined aquifer beneath this site is considered slight since the lithology of the Mehrten Formation beneath Site 4 is believed to be the same as beneath Site 3.

Site 5 - Northest Perimeter Landfill No. 3

Two wells were drilled downgradient from Site 5 (see Figure IV-9). Sampling showed that PCE, DCE and 1,2-dichloropropane are present in low concentrations in the northern well (MAFB-23), but no contaminants are present in the southern well (MAFB-22). MAFB-22 and 23 are also located downgradient of Site 4, with MAFB-23 being more directly in line with the groundwater flow from

Geophysical investigation at the site showed a shallow conductive zone moving south from the site toward the RV storage area. This appears to be a near-surface feature only.

This landfill, which is quite small, was in use for only one year (1971). Solvents and/or POL wastes were not reported to have been dumped here. The potential for current leachate generation from this site is very small, particularly since the site has been closed for 15 years. We do not consider Site 5 to be a potential hazard to groundwater quality, but believe that these wells are showing movement of solvents from Site 4.

Summary

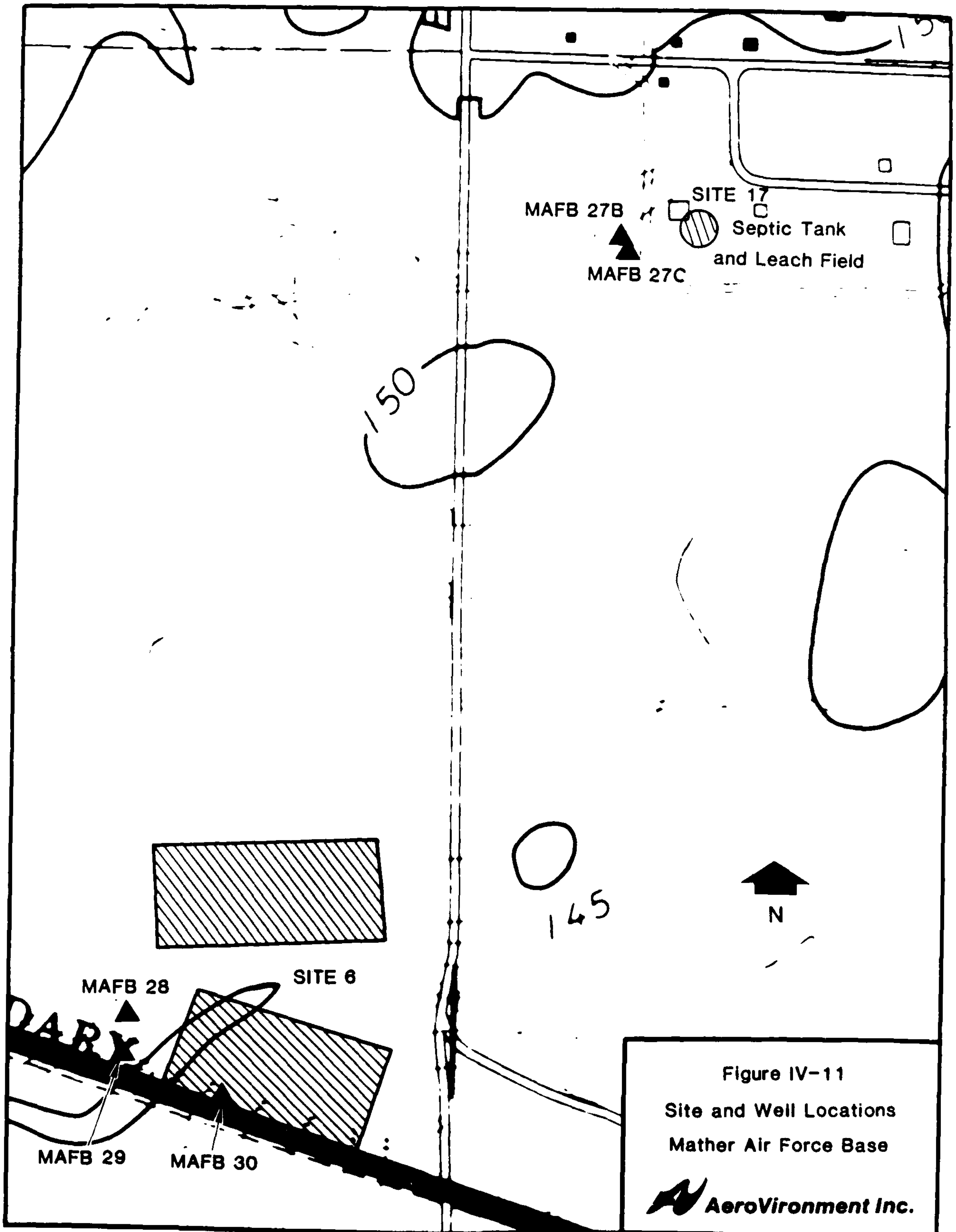
Eleven groundwater monitoring wells were installed and sampled at the four landfill sites in Area No. 1. The wells downgradient from Sites No. 3 and No. 4 are contaminated with PCE and other solvents (all six wells at these sites exceeded PCE action levels). This is not surprising, because these two sites reportedly received waste solvents and POL. Unfortunately, no compatible upgradient well exists. There are several known groundwater contamination problems at properties upgradient of Mather AFB and, without an upgradient sampling location, final conclusions cannot be drawn.

Four of the five wells installed at Sites 2 and 5 were free of contamination. The exception is MAFB-23 at Site 5. This well shows contamination, but it appears to be coming from other sites on base, which are further upgradient.

Area 2

Site 17 - Weapon Storage Area Septic Tank

Two wells were installed at Site 17 (see Figure IV-11). The first, MAFB-27-B, was drilled to 122 feet and the screened interval was 98-118 feet below ground surface. This was after the first two attempts at installing a well (DH-27 and 27-A) were aborted and filled with concrete due to drilling and



Scale: 1" = 500'

June 1986

Reference: USGS Topo maps and USAF Master Plan for Mather AFB, 30 Sept. 83.

construction problems. After MAFB-27-B was completed, it was found that the screened area was above the water table. A second well, MAFB-27-C, was then installed at the site. This well was drilled to 142 feet and the screen was set at 118-138 feet. MAFB-27-C was sampled and found to be clean.

Groundwater below Site 17 does not appear to be affected by the old septic tank at the weapons storage. This finding was expected because of the nature of material placed into the septic system.

Site 6 - Firing Range Landfill

Three wells were installed downgradient of Site 6 (see Figure IV-11). The laboratory results showed no contamination in any of the wells. This was expected, as the landfill was used for disposal of domestic and office waste in the 1970s, but not for shop waste. The southeast corner of the base, then, which includes Sites 17 and 6, does not seem to have a problem with contamination of the water table aquifer.

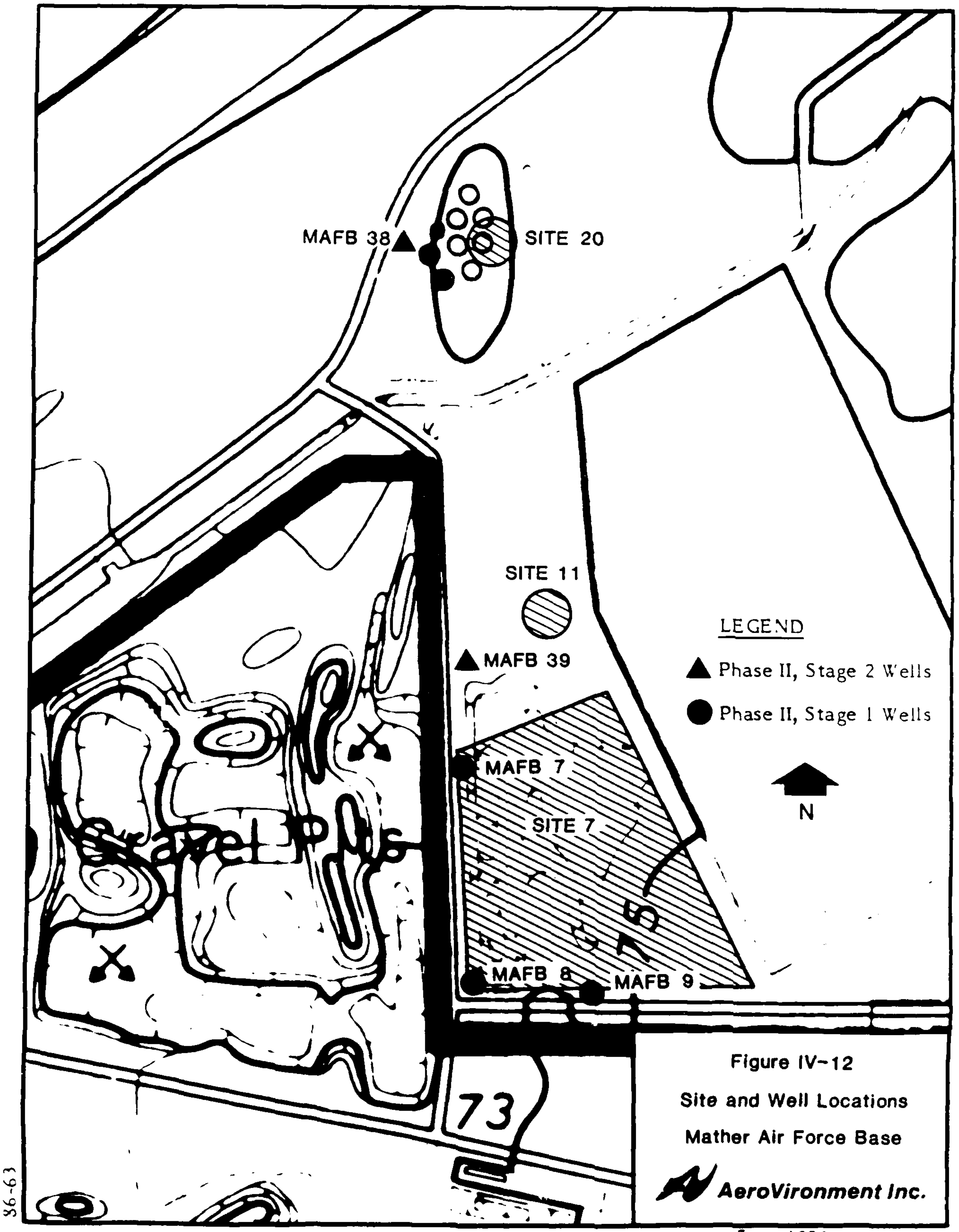
Summary

The water table in this corner of the base is relatively deep, from 120 to 130 feet below ground surface, and is protected by thick clay and silt layers. Although small amounts of POL wastes may have been disposed at these sites, all wells in the area were clean. Ground water contamination of either water table or confined aquifers in this area is considered to be unlikely.

Area 3

Site 20 - MOGAS Spill Site

One well, MAFB-38, was installed downgradient of the old sewage plant (see Figure IV-12). This well was completed in a large perched water zone that has been found to cover much of the southwest corner of the base. This perched water was encountered in one of the three wells drilled at Site 7 during the Phase II, Stage 1 effort (as well as in MAFB-39 at Site 11).



Scale: 1" = 400'

June 1986

Reference: USGS Topo maps and USAF Master Plan for Mather AFB, 30 Sept. 83

Our sampling of MAFB-38 showed no contamination. If fuel had percolated at this site, it would have first encountered the large perched zone, instead of the regional water table, assuming the perched zone was present at the time of the MOGAS spill. It is believed that this was because the static water level in MAFB-9 (Site 7) has been relatively steady since May of 1984. The perched water does not appear to be a seasonal phenomenon.

Site 11 - Existing Fire Training Area (1958-1984)

As mentioned above, MAFB-39, drilled downgradient from Site 11, encountered a large perched water zone. The existing FPTA is within 400 feet of Site 7, which was investigated during Phase II, Stage 1 (Figure IV-12). Site 7 had three wells installed: MAFB-7, 8, and 9. MAFB-9 also encountered perched water, but the other two have SWL readings which indicate that they are screened in the water table aquifer. Perched water zones are common in this geographic area. A large well-defined area of perched water has been identified during drilling and sampling at the Aerojet General Corporation site to the northeast of the base. Figure IV-6 shows the area of known perched water; it may be much larger than shown because we do not have information on other areas of the base. The recharge source for this zone may be the gravel pit just west of the base boundary, direct surface infiltration through the gravels found just below the surface, or percolation from the unlined oxidation ponds northeast of the site.

No contamination was discovered in groundwater downgradient from Site 11.

Summary

No groundwater contamination exists in the perched water zone, as examined at the two sites in this area. The extent of the perched water is not known. It is believed that the water table aquifer is rot endangered by these sites.

Area 4

Site 10A - Fire Department Training Area No. 3 (Assumed)

This site was originally thought to be Site 10. However, an analysis of historic air photos has shown that the actual Site 10, which we call 10B, was really southwest of the fire station in an area that is now covered by the tanker loading area (see Figure IV-13). Figure IV-14 is an aerial photograph taken in 1955, which shows the actual fire training area. The current use of the site is shown by the photo in Figure I-2 which was taken since the tanker loading area was built.

Prior to checking the air photo collection at the base, the geophysical survey was run on Site 10A. A long, high-conductivity zone was discovered on the west edge of the site.

Based on the information from the geophysical study and the air photo data, the project scope of work was changed slightly to account for these conditions:

- No geophysical work or soil borings would be done at Site 10B because the site was completely covered with reinforced concrete.
- One of the two wells originally scheduled for Site 10 was drilled downgradient from Site 10B.
- The two soil borings scheduled for Site 10 were used to investigate the shallow anomally found at Site 10A.
- One well was installed downgradient from Site 10A to investigate groundwater conditions and provide upgradient data for Site 10B.

MAFB-36 was drilled downgradient from Site 10A. The groundwater was found to contain 1.2 and 2.6 ppb of TCE in the two sampling rounds. The TCE

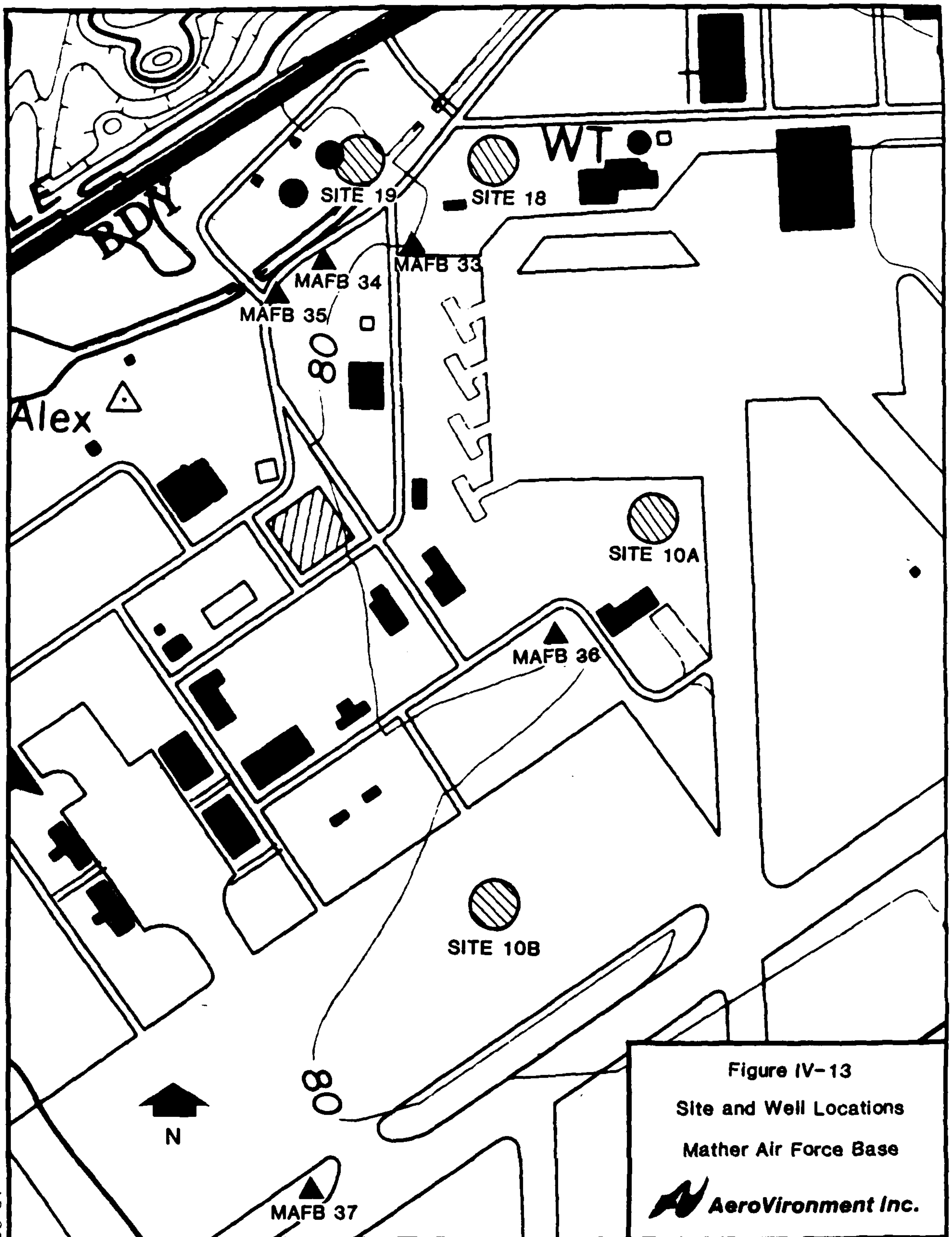


Figure IV-13

Site and Well Locations

Mather Air Force Base

AeroVironment Inc.

June 1986

Scale: 1" = 500'

Reference USGS Topo maps and USAF Master Plan for Mather AFB, 30 Sept. 83.

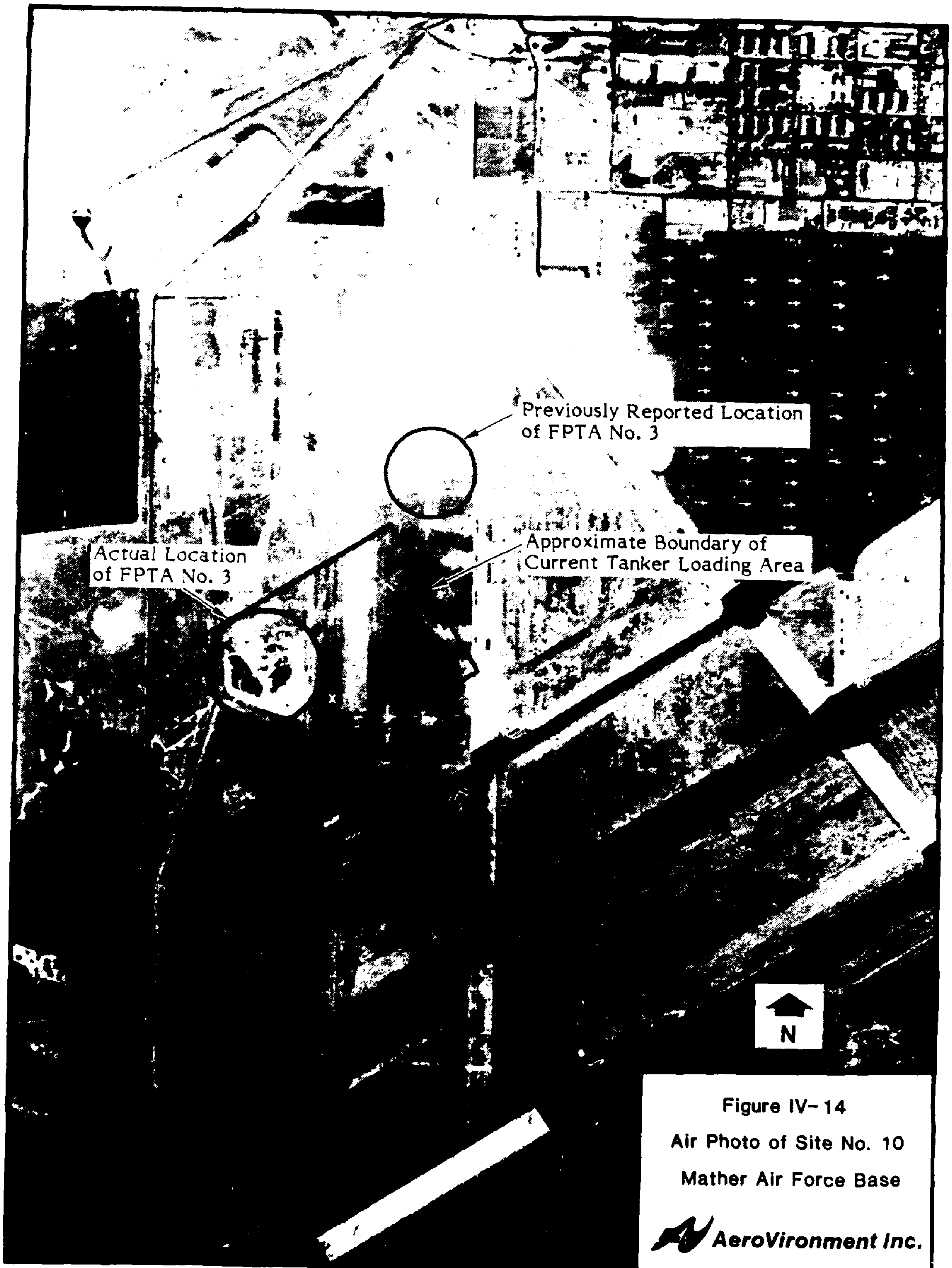


Figure IV-14
Air Photo of Site No. 10
Mather Air Force Base

AeroVironment Inc.

Photograph Taken 1955

June 1986

is thought to be the result of upgradient source(s) which will be discussed later. Soil sampling in the area of the geophysical anomally did not indicate any levels of organic or inorganic chemicals elevated above normal background. Nothing was found to indicate that groundwater contamination from the surface should be a problem at this site.

Site 10B - Fire Department Training Area (Actual)

One well, MAFB-37, was drilled downgradient from the location identified in old air photos. The two sampling rounds found 1.5 and 1.4 ppb of TCE in the groundwater. It cannot be from the site being investigated. According to base records, TCE was not used at Mather AFB until 1958. An air photo dated March 1958 shows the present tanker loading area being built over Site 10B, so the FPTA must have ceased operating several months prior to March 1958. With the tanker-loading area in place, rainfall was removed as a hydraulic driving force and any residual organics in the soil would be trapped on or very near the site. The TCE found in MAFB-37 at this site is thought to be the result of an upgradient source.

Site 19 - Fuel Tank Sludge Burial Site

Two wells were installed downgradient from the fuel tank sludge burial site (Figure IV-13). Both were found to be clean. The geophysical investigation around the burial site found many buried pipes, but no obvious zone of contamination. Since the site is within the diked area containing the two main above-ground fuel storage tanks for the base, we were unable to use the hollow-stem auger as planned. Hand augers were used as a substitute method. Three hand auger borings were drilled and samples taken at the ground surface and at two feet below the surface. Since the fuel tank sludge was buried in shallow hand-dug pits, the maximum sampling depth of two feet was considered sufficient to intercept any contamination present. None of the samples contained elevated levels of volatile organic compounds, oil and grease, or lead, parameters which would be characteristic of the waste material. There is no evidence, either direct or indirect, of groundwater or soil contamination from this site.

Site 18 - Old Burial Site

One well, MAFB-33, was installed downgradient from Site 18 (Figure IV-13). The site is currently covered by a parking lot adjacent to Building 4120. No TCE or other solvents are suspected of being buried at the site, although it may have been a general refuse landfill during the late 1940's.

MAFB-33 is highly contaminated with TCE. The two sample rounds found 67 and 55 ppb of TCE, respectively, in the groundwater. This is well over the DOHS action level of 5 ppb. We do not believe that the TCE found in the water is being generated by Site 18, but that it is being transported under the base through the superjacent stream channel deposits that were described in Section IV.A (see Figure IV-1) as possible contamination pathways. This stream channel system provides a direct, highly permeable pathway from potential source areas upgradient from Mather AFB. The channel runs through the northwest corner of the base. These upgradient areas have a history of problems with TCE groundwater. The California Department of Water Resources (CDWR, 1974) has reported that these stream channel deposits have groundwater velocities of up to 30 feet per day. Groundwater could conceivably travel from the potential source areas to Mather AFB in two to three years.

MAFB-33 is located less than 350 feet from MAFB-34, and less than 550 feet from MAFB-35, but TCE was not found in either of the other two wells. During drilling, the lithology of all three wells was very similar, but MAFB-33 was the only one that produced a large amount of water during development. The well screen on MAFB-33 is set at 95 feet, which is 13 feet deeper than the screens at MAFB-34 and 35. This may explain the difference in pumping rates between the wells. The MAFB-33 screen is set 35 feet higher than wells in the off-base mobile home park.

During the Phase II, Stage 1 study, two groundwater monitoring wells (MAFB-10 and 11) were installed along the western edge of Mather AFB near Site 15. These wells are located downgradient from MAFB-33 and Site 18. Samples were not collected from MAFB-10 and 11 during this survey. At the time

of their last sampling in June 1985, neither of the wells showed any significant concentrations of volatile organic compounds. However, the Phase I report refered to off-base domestic wells, located just west of Mather AFB and Site 15, which had been sampled and found to contain high levels of TCE. We believe that MAFB-10 and 11 are: 1) located outside of the stream channel previously discussed, and 2) were screened too far above the top of the water table. As a result, they are not showing the TCE contamination that is being found both upgradient and downgradient of their location. It appears that even though MAFB-10 and 11 are clean, TCE contamination is spreading off the western edge of Mather AFB. The exact direction of groundwater flow has yet to be resolved, however.

Summary

Six groundwater monitoring wells were installed and sampled at the four sites in Area No. 4. The wells downgradient from Sites 10A and 10B showed low levels of TCE, but were below the DOHS action level. Site 19, the fuel tank sludge burial site, does not show any evidence of groundwater contamination. Site 18 has very elevated TCE levels in the downgradient well, but this may be due to contaminated water being transported onto Mather AFB from a potential TCE source area located off base (upgradient). Off-base (downgradient) migration of groundwater contaminated with TCE may also be occurring. Soil samples taken at Sites 10A and 19 did not show any contamination.

Area 5

Site 14 - Drainage Ditch Site 2

AeroVironment drilled two wells downgradient from drainage ditch No. 2 (see Figure IV-15). They were sited specifically to detect possible contamination from the ditch before it could reach base supply wells MB-2 and MB-3 (MB is the abbreviation used by Mather AFB for its production wells). One of the monitoring wells, MAFB-31, has high levels of TCE. The two sample rounds had 22 and 23 ppb of TCE, respectively. MAFB-32 was found to be clean.

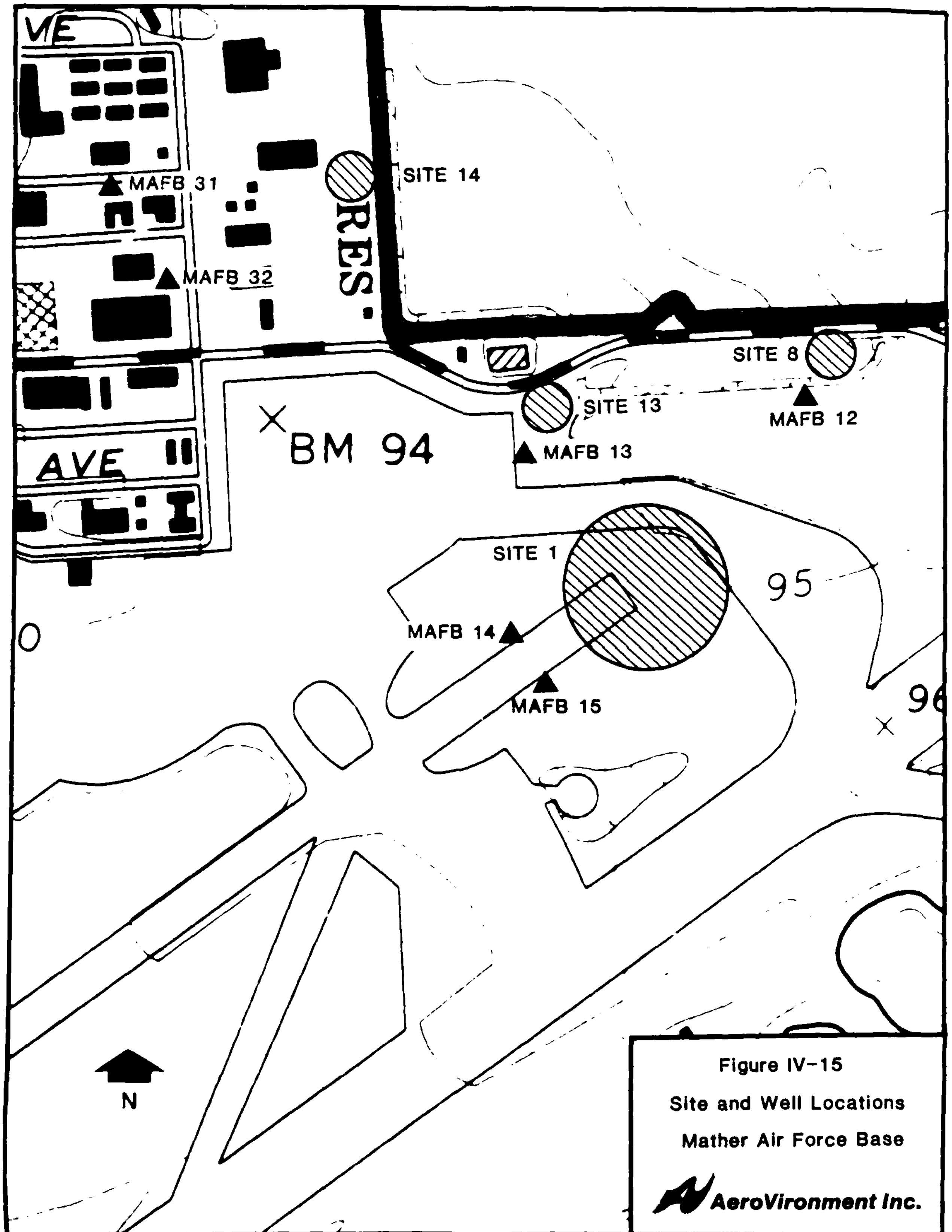


Figure IV-15
Site and Well Locations
Mather Air Force Base

AeroVironment Inc.

June 1986

86-65

Scale: 1" = 500'

Reference: USGS Topo maps and USAF Master Plan for Mather AFB, 30 Sept. 83.

MAFB-31 is located approximately 500 feet from base supply well MB-3. The cone of depression formed by this large pumping well probably controls groundwater flow in the area. When it was installed in 1943, MB-3 was gravel packed from its total depth of 501 feet to the surface. Thus, contaminated water from the water table could easily migrate down the gravel pack and into the confined aquifers that are used for municipal water supply in the area. (The inadequate surface seal could also enable contaminants to travel from the surface into the confined aquifers.)

Site 14 may be the source of the TCE that was found in MAFB-31. The same buried stream channel deposit that is suspected of causing problems at Site 18 is also reported to be found in the area of MAFB-31 (CDWR, 1974). Without further investigation, the actual source of the TCE cannot be pinpointed.

During the Phase II, Stage 1 IRP study, an upgradient well (MAFB-6) was installed along the northern edge of the base. This well was not sampled as part of the Phase II, Stage 2 effort. MAFB-6 is not situated upgradient from either base supply well MB-3 or Site 14, so it should not be used as an upgradient well for comparing results from MAFB-31. When it was last sampled in June, 1985, MAFB-6 was found to be essentially clean with only a trace of TCE detected. While this seems to indicate that the TCE found in MAFB-31 and 33 is a direct result of activities at Mather AFB, it would be wise to drill more appropriately located upgradient well(s) before drawing final conclusions about northwest corner problems.

Site 13 - Drainage Ditch No. 1

Groundwater downgradient from Site 13 (Figure IV-15) was monitored with one well, MAFB-13. Low levels of TCE, 1.6 and 2.0 ppb for the two sampling rounds, were found in this well along with DCE and PCE. From 25 to 75 feet below the ground surface, MAFB-13 penetrated a sticky clay. Directly overlying the clay is a sand and gravel zone that was noted as having perched water during the drilling of the well. It is probable that any TCE from Site 13 would percolate down to the perched water at 25 feet and would be effectively stopped by a clay zone 50 feet

thick. The low-level contamination found in MAFB-13 could quite likely have another, unknown source.

If the water table aquifer in this area is contaminated with low-level amounts of TCE from an off-site source or Site 13, then production well MB-1, which is 450 feet northwest of MAFB-13 could also be effected. MB-1 is constructed much like MB-3 and lacks an adequate sanitary seal. The well has 273 feet of screened interval in five zones from 262 to 577 feet below the ground surface. During pumping, the cone of depression from the well could easily spread past Drainage Ditch No. 1 and draw any contaminated water from the site into the well.

Site 1 - Runway Overrun Landfill

The Runway Landfill (Figure IV-15) was monitored by two downgradient wells, MAFB-14 and MAFB-15. Low to moderate levels of a number of solvents have been detected in the wells. For our two sample rounds, MAFB-14 was found to have 6.5/7.3 ppb of DCE and 2.4/2.4 ppb of TCE. MAFB-15 was found to contain 8.3/11.0 ppb of DCE, 8.9/9.7 ppb of PCE as well as 1.5/1.5 ppb of TCE. The DOHS action level of 4 ppb for PCE is more than doubled, and the other two solvents are high enough to cause concern.

Geophysical surveys run before the drilling program showed that much of the old landfill is currently covered by the asphalt overrun of Runway 22R. This would limit the hydraulic driving force necessary to move leachate from the site.

It is unlikely that this wide assortment of solvents has been introduced into the groundwater from this site. The landfill was closed in 1942; TCE was not reported to be in use on base until 1958. A landfill of this nature would be unlikely to be producing volatile organic leachate because (1) while it was active the quantity of solvents possibly dumped into it was quite small, and (2) the landfill is covered with asphalt, so there is no consistent driving force for leachate generation and movement.

The more reasonable assumption, for some, if not all of the solvents, is that they have migrated into the area from somewhere other than Site 1. The groundwater along the entire northeast perimeter of the base seems to be contaminated with PCE, TCE and DCE, so it is very possible that contamination at Site 1 is the result of some of the same sources causing those problems.

The nearest production well is 900 feet from the site, and cross-gradient. If Site 1 has generated all of the solvents found in the monitoring wells, then MB-1 will probably not be affected (MB-1 is screened in five zones from 262 feet to 577 feet). If the solvents are found to be ubiquitous in the water table aquifer in this general area of the base, then water quality at MB-1 may be impacted in the future. Fortunately, MB-1 draws its water from confined aquifers which do not appear to be contaminated at this time.

Site 8 - Fire Department Training Area No. 1

MAFB-12 was installed downgradient from the assumed location of Site 8 (Figure IV-15). The geophysical investigation and inspection of historical aerial photographs were unable to pinpoint the old site, which has not been used since 1945. This site is about 1000 feet upgradient from Site 1. PCE (8.2/8.4 ppb), DCE (8.6/9.8 ppb), TCE and 1,2-Dichloropropane were consistently present in significant concentrations. The PCE concentrations are very similar to those found at Site 1; they also exceed the DOHS action level by an appreciable margin.

The water table is protected by a 40-foot thick zone of silty clay from 25 to 65 feet below ground surface, which should inhibit vertical migration of any plumes coming from the site. It is probable that not many solvents were in use on base by the time the site was closed in 1945. Once again, the most plausable source of contamination in MAFB-12 is an upgradient source and not the site in question.

Summary

Four sites are found in Area 5, and they are being monitored by six wells set in the water table aquifer. The water table in the area is theoretically protected from contamination from surface or shallow sources by a 40- to 60-foot thick layer of clay. However, base production wells MB-1, MB-2, and MB-3 do not have proper sanitary seals and may serve as conduits for contamination from the water table to move to deeper zones. Some of the contamination that was identified in the water table aquifer may originate off base and be migrating through a large, well-defined stream channel deposit.

V. ALTERNATIVE MEASURES

Fifteen potential hazardous waste sites were investigated during the Phase II, Stage 2 IRP study at Mather AFB. Possible groundwater contamination is the concern at all of the sites coming from a variety of point or nonpoint sources. Shallow soil contamination is not considered significant at any of the sites. Since the basic problem is the same for all sites, the available options for each site will likewise be the same. This chapter presents the possible options which may be appropriate for each site as part of the IRP Phase II. In the first part of the chapter (V.A), the five basic options are discussed. In the second part of the chapter (V.B), we have listed those options which apply to each of the sites studied in Phase II Stage 2. Specific site recommendations will be presented in Chapter VI.

A. Description of Options

1. Option 1 - No Action

No further action need be taken if it has been determined that: a) there is no evidence of soil or groundwater contamination or, b) the amount of contamination found is within acceptable limits and poses no serious threat to the environment. Wells would be maintained only for water level information.

2. Option 2 - Continued Monitoring of Existing Wells

Existing wells may continue to be monitored if: 1) a low-level plume is present and the continued monitoring would be used to establish a periodic sampling program as a safety measure; 2) a plume is not now present, but changing conditions may cause a plume to form; 3) the site is up gradient from municipal or domestic supply wells and the wells could be used as an early warning system to protect water quality. Wells would be sampled and analyzed periodically for specific compounds. Water levels would also be monitored.

3. Option 3 - Use Existing Wells to Monitor Other Sites

Existing wells at sites which pose no environmental threat, located close to other sites which are thought to be problems could be used as either up-gradient or additional down-gradient wells for these problematic sites. For example, a well that is down gradient from a site that has been shown to be clean may be used as an up-gradient well for another nearby site. Under this option, wells would be sampled periodically for the parameters of concern at the problematic site(s). Water levels would also be monitored.

4. Option 4 - Install More Wells

More groundwater monitoring wells might be installed if additional wells are required up gradient or down gradient of a site. These wells would be used to verify the quality of water entering the site, or to determine the horizontal or vertical orientation of a plume being generated by a site. Shallow wells would be suggested to determine horizontal migration of known upper aquifer contamination. Deep wells would be used to check for vertical movement into the lower aquifers.

A few sites are up gradient from base supply wells. The lower formations that yield water to the supply wells should probably be monitored. Any deep monitoring wells recommended near production wells would need to be screened in the same zone as the uppermost screened area of the supply well.

5. Option 5 - Corrective Action, Move to Phase IV

If groundwater contamination is proven to be coming from a site, and it poses a serious and immediate threat to the environment, corrective action should be taken. This could involve extraction, treatment and reinjection of contaminated water; in-situ remediation; supplying alternative water sources; or other available technology developed in an IRP Phase III research study.

Soil excavation is not considered appropriate for any of the sites at Mather AFB, because the waste sites are generally large and old, so that potential contamination has been widely dispersed from its original source area.

Chapter VI presents AeroVironment's specific recommendations for each site investigated during the Phase II, Stage 2 effort. All of the sites fall into one of the basic categories presented above. Two of the sites are appropriate for some additional geophysical work, but this would be very limited in scope. Because this type of work is limited to specific sites, it will not be mentioned in this chapter as an option, but will be discussed in Chapter VI. In addition to the specific action (if any) recommended, we will present the reasoning for, and objective of, the proposed action.

B. Site Specific Options

Area 1

Site 2 — "8150" Area Landfill

Option 1	No action. This option would be appropriate for this site because no evidence of contamination was found during this study.
Option 2	Continued monitoring of existing wells. This option could be used to continue monitoring for contaminants, even though none were found during this study. However, this action is not considered necessary.
Option 3	Use existing wells to monitor other sites. This option would be appropriate because of the close proximity of other IRP sites to the wells drilled at this site.
Option 4	Install more wells. This option is not justified at this site because no contamination was found.
Option 5	Corrective action, move to Phase IV. This option is not justified at this site because no contamination was found.

Site 3 — Northeast Perimeter Landfill No. 1

Option 1	No action. This option is not appropriate at this site, because TCE, DCE and PCE contamination was identified in wells down-gradient from this site.
Option 2	Continued monitoring of existing wells. This option is appropriate for this site because of the contamination identified in groundwater wells.
Option 3	Use existing wells to monitor other sites. This option is not directly appropriate because the primary function of wells at this site is to monitor conditions at this site. However, because of the close proximity of this site to other IRP sites, wells at this site may be useful in providing additional information at other sites.
Option 4	Install more wells. This option is appropriate because of the contamination found in groundwater downgradient from this site. Additional wells are justified to further define the vertical and lateral contamination at this site, in addition to continued monitoring of existing wells.
Option 5	Corrective action, move to Phase IV. Although this option may ultimately be appropriate for this site, it is premature to move to Phase IV at this time. The full magnitude of the contamination at this site has not been fully defined.

Site 4 — Northeast Perimeter Landfill No. 2

Option 1	No action. This option is not appropriate at this site, because TCE, DCE and PCE contamination was identified in wells down-gradient from this site.
Option 2	Continued monitoring of existing wells. This option is appropriate for this site because of the contamination identified in groundwater wells.
Option 3	Use existing wells to monitor other sites. This option is not directly appropriate because the primary function of wells at this site is to monitor conditions at this site. However, because of the close proximity of this site to other IRP sites, wells at this site may be useful in providing additional information at other sites.

Option 4 — Install more wells.
This option is appropriate because of the contamination found in groundwater downgradient from this site. Additional wells are justified to further define the vertical and lateral contamination at this site, in addition to continued monitoring of existing wells.

Option 5 — Corrective action, move to Phase IV.
Although this option may ultimately be appropriate for this site, it is premature to move to Phase IV at this time. The full magnitude of the contamination at this site has not been fully defined.

Site 5 — Northeast Perimeter Landfill No. 3

Option 1 — No action.
This option is not appropriate at this site, because PCE contamination was identified in wells downgradient from this site.

Option 2 — Continued monitoring of existing wells.
This option is appropriate for this site because of the contamination identified in groundwater wells.

Option 3 — Use existing wells to monitor other sites.
This option is not directly appropriate because the primary function of wells at this site is to monitor conditions at this site. However, because of the close proximity of this site to other IRP sites, wells at this site may be useful in providing additional information at other sites.

Option 4 — Install more wells.
This option may be appropriate, based on further evaluation of the location of the groundwater plume. If more wells are needed, they would be in addition to continued monitoring of existing wells.

Option 5 — Corrective action, move to Phase IV.
Although this option may ultimately be appropriate for this site, it is premature to move to Phase IV at this time. The full magnitude of the contamination at this site has not been fully defined.

Area 2

Site 6 — Firing Range Landfill

Option 1	No action. This option would be appropriate for this site because no evidence of contamination was found during this study.
Option 2	Continued monitoring of existing wells. This option could be used to continue monitoring for contaminants, even though none were found during this study. However, this action is not considered necessary.
Option 3	Use existing wells to monitor other sites. This option would not be appropriate because this site is not located close enough to other IRP sites to provide useful information on them.
Option 4	Install more wells. This option is not justified at this site because no contamination was found.
Option 5	Corrective action, move to Phase IV. This option is not justified at this site because no contamination was found.

Site 17 — Weapons Storage Area Septic Tank

Option 1	No action. This option would be appropriate for this site because no evidence of contamination was found during this study.
Option 2	Continued monitoring of existing wells. This option could be used to continue monitoring for contaminants, even though none were found during this study. However, this action is not considered necessary.
Option 3	Use existing wells to monitor other sites. This option would not be appropriate because this site is not located close enough to other IRP sites to provide useful information on them.
Option 4	Install more wells. This option is not justified at this site because no contamination was found.

Option 5 — Corrective action, move to Phase IV.
This option is not justified at this site because no contamination was found.

Area 3

Site 20 — MOGAS Spill Site

Option 1 — No action.
This option would be appropriate for this site because no evidence of contamination was found during this study.

Option 2 — Continued monitoring of existing wells.
This option could be used to continue monitoring for contaminants, even though none were found during this study. However, this action is not considered necessary.

Option 3 — Use existing wells to monitor other sites.
This option would not be appropriate because this site is not located close enough to other IRP sites to provide useful information on them.

Option 4 — Install more wells.
This option is not justified at this site because no contamination was found.

Option 5 — Corrective action, move to Phase IV.
This option is not justified at this site because no contamination was found.

Site 11 — Existing Fire Protection Training Area (1958-1984)

Option 1 — No action.
This option would be appropriate for this site because no evidence of contamination was found during this study.

Option 2 — Continued monitoring of existing wells.
This option could be used to continue monitoring for contaminants, even though none were found during this study. However, this action is not considered necessary.

Option 3 — Use existing wells to monitor other sites.
This option would be appropriate because of the close proximity of other IRP sites to the wells drilled at this site.

Option 4 | Install more wells. This option is not justified at this site because no contamination was found.

Option 5 | Corrective action, move to Phase IV. This option is not justified at this site because no contamination was found.

<u>Area 4</u>

Site 10 (A & B) — Fire Protection Training Area No. 3

Option 1 | No action. This option is not appropriate at this site, because a low level of TCE contamination was identified in wells downgradient from this site.

Option 2 | Continued monitoring of existing wells. This option is appropriate for this site because of the contamination identified in groundwater wells.

Option 3 | Use existing wells to monitor other sites. This option is not directly appropriate because the primary function of wells at this site is to monitor conditions at this site. However, because of the close proximity of this site to other IRP sites, wells at this site may be useful in providing additional information at other sites.

Option 4 | Install more wells. Although this option could be used at this site, it is not considered necessary at this time. The concentrations of contaminants found in existing wells are below DOHS action levels. If continued monitoring shows increasing concentrations, this option would be justified.

Option 5 | Corrective action, move to Phase IV. Although this option may ultimately be appropriate for this site, it is premature to move to Phase IV at this time. The full magnitude of the contamination at this site has not been fully defined.

Site 19 — Fuel Tank Sludge Burial Site

Option 1 | No action. This option would be appropriate for this site because no evidence of contamination was found during this study.

Option 2 — Continued monitoring of existing wells.
This option could be used to continue monitoring for contaminants, even though none were found during this study. However, this action is not considered necessary.

Option 3 — Use existing wells to monitor other sites.
This option would be appropriate because of the close proximity of other IRP sites to the wells drilled at this site.

Option 4 — Install more wells.
This option is not justified at this site because no contamination was found.

Option 5 — Corrective action, move to Phase IV.
This option is not justified at this site because no contamination was found.

Site 18 — Old Burial Site

Option 1 — No action.
This option is not appropriate at this site, because TCE contamination was identified in wells downgradient from this site.

Option 2 — Continued monitoring of existing wells.
This option is appropriate for this site because of the contamination identified in groundwater wells.

Option 3 — Use existing wells to monitor other sites.
This option is not directly appropriate because the primary function of wells at this site is to monitor conditions at this site. However, because of the close proximity of this site to other IRP sites, wells at this site may be useful in providing additional information at other sites.

Option 4 — Install more wells.
This option is appropriate because of the contamination found in groundwater downgradient from this site. Additional wells are justified to further define the problem at this site, in addition to continued monitoring of existing wells.

Option 5 — Corrective action, move to Phase IV.
Although this option may ultimately be appropriate for this site, it is premature to move to Phase IV at this time. The full magnitude of the contamination at this site has not been fully defined.

Site 14 — Drainage Ditch Site No. 2

Option 1 — No action.
This option is not appropriate at this site, because TCE contamination was identified in wells downgradient from this site.

Option 2 — Continued monitoring of existing wells.
This option is appropriate for this site because of the contamination identified in groundwater wells.

Option 3 — Use existing wells to monitor other sites.
This option is not directly appropriate because the primary function of wells at this site is to monitor conditions at this site. However, because of the close proximity of this site to other IRP sites, wells at this site may be useful in providing additional information at other sites.

Option 4 — Install more wells.
This option is appropriate because of the contamination found in groundwater downgradient from this site. Additional wells are justified to further define the problem at this site, in addition to continued monitoring of existing wells.

Option 5 — Corrective action, move to Phase IV.
Although this option may ultimately be appropriate for this site, it is premature to move to Phase IV at this time. The full magnitude of the contamination at this site has not been fully defined.

Site 13 — Drainage Ditch Site No. 1

Option 1 — No action.
This option is not appropriate at this site, because TCE, DCE and PCE contamination was identified in wells downgradient from this site.

Option 2 — Continued monitoring of existing wells.
This option is appropriate for this site because of the contamination identified in groundwater wells.

Option 3 — Use existing wells to monitor other sites.
This option is not directly appropriate because the primary function of wells at this site is to monitor conditions at this

site. However, because of the close proximity of this site to other IRP sites, wells at this site may be useful in providing additional information at other sites.

Option 4 — Install more wells.
Although this option could be used at this site, it is not considerednecessary at this time. The concentrations of contaminants found in existing wells are below DOHS action levels. If continued monitoring shows increasing concentrations, this option would be justified.

Option 5 — Corrective action, move to Phase IV.
Although this option may ultimately be appropriate for this site, it is premature to move to Phase IV at this time. The full magnitude of the contamination at this site has not been fully defined.

Site 8 — Fire Protection Training Area No. 1

Option 1 — No action.
This option is not appropriate at this site, because PCE contamination was identified in wells downgradient from this site.

Option 2 — Continued monitoring of existing wells.
This option is appropriate for this site because of the contamination identified in groundwater wells.

Option 3 — Use existing wells to monitor other sites.
This option is not directly appropriate because the primary function of wells at this site is to monitor conditions at this site. However, because of the close proximity of this site to other IRP sites, wells at this site may be useful in providing additional information at other sites.

Option 4 — Install more wells.
This option is appropriate because of the contamination found in groundwater downgradient from this site. Additional wells are justified to further define the problem at this site, in addition to continued monitoring of existing wells.

Option 5 — Corrective action, move to Phase IV.
Although this option may ultimately be appropriate for this site, it is premature to move to Phase IV at this time. The full magnitude of the contamination at this site has not been fully defined.

Site 1 — Runway Overrun Landfill

Option 1	No action. This option is not appropriate at this site, because PCE, TCE, DCE and 1,2-Dichloropropane contamination was identified in wells downgradient from this site.
Option 2	Continued monitoring of existing wells. This option is appropriate for this site because of the contamination identified in groundwater wells.
Option 3	Use existing wells to monitor other sites. This option is not directly appropriate because the primary function of wells at this site is to monitor conditions at this site. However, because of the close proximity of this site to other IRP sites, wells at this site may be useful in providing additional information at other sites.
Option 4	Install more wells. This option is appropriate because of the contamination found in groundwater downgradient from this site. Additional wells are justified to further define the problem at this site, in addition to continued monitoring of existing wells.
Option 5	Corrective action, move to Phase IV. Although this option may ultimately be appropriate for this site, it is premature to move to Phase IV at this time. The full magnitude of the contamination at this site has not been fully defined.

VI. RECOMMENDATIONS

This chapter outlines AeroVironment's recommendations for further work related to the IRP program at Mather AFB. As requested by the Air Force, we have assigned a category designation to each site. The following definitions apply to these categories:

> Category I: Sites where no further action (including remedial action) is required
>
> Category II: Sites requiring additional monitoring or work to quantify or further assess the extent of current or future contamination
>
> Category III: Sites that will require remedial action (ready for IRP Phase IV action)

Of the 15 sites investigated during this stage, 6 are considered to be Category I sites. All of the remaining nine sites are classified as Category II. The Category II sites may be further broken down into those which only require continued monitoring of existing wells and those which need additional wells to investigate the sites more thoroughly. No Category III sites have been identified during this stage. The recommendations are summarized in Table VI-1.

Specific recommendations are made below, but note that those recommendations which require further wells to be drilled are based only on the current level of knowledge of the subsurface conditions and groundwater flow patterns around Mather AFB. For example, decisions about the actual depths of the borings will have to be made by field personnel based on the specific field conditions that are encountered. The problems identified during this study are not specific to single sites. The groundwater contamination is spread over significant areas of the base and as a result, future monitoring should be thought of as an area-wide program, not site specific. Many existing or proposed groundwater monitoring wells will be useful in defining problems at several sites, not just the site for which they are primarily associated. This includes wells and sites which were/are part of Phase II,

TABLE VI-1. Summary of recommendations.

Site	Recommendation
No. 2, "8150" Landfill (Category I)	- No additional work is needed. However, the wells at this site may be useful monitoring locations for Sites No. 3, 4, and 5 at some time in the future.
No. 3, Landfill No. 1 (Category II)	- Install 3 additional groundwater monitoring wells: 1 shallow upgradient 1 deep upgradient 1 deep downgradient - Sample 6 wells (3 existing and 3 proposed) semiannually, and test for VOAs (Method 601)
No. 4, Landfill No. 2 (Category II)	- Install 2 additional groundwater monitoring wells: 1 deep downgradient 1 shallow upgradient (replace MAFB-5) - Abandon MAFB-5 by grouting the well according to State of California and Sacramento County standards. - Incorporate the Phase II, Stage 3 deep upgradient well into the monitoring plan for this site. - Sample 6 wells (3 existing, 1 planned, 2 proposed) semiannually, and test for VOAs (Method 601)
No. 5, Landfill No. 3 (Cateogry II)	- Conduct a geophysical study (electrical conductivity) to trace the identified plume to its endpoint. - If the plume appears to extend beyond the existing monitoring well system, install an additional well to monitor the plume. - Sample the 2 existing wells semiannually, and test for VOAs (Method 601)
No. 6, Firing Range LF (Cateogry I)	- No additional work is needed.
No. 17, Weapons Storage (Category I)	- No additional work is needed.
No. 20, MOGAS Spill (Category I)	- No additional work is needed.
No. 11, Existing FPTA (Category I)	- No additional work is needed. However, MAFB-39 may be a useful monitoring location for other IRP sites at some time in the future.
No. 10(A&B), FPTA No. 3 (Category II)	- Sample the two wells at these locations semi-annually and test for VOAs (Method 601). - Conduct additional geophysical study (electrical conductivity) to define the anomaly tentatively identified in this study.
No. 19, Fuel Tank Burial (Category I)	- No additional work is needed for this site (Use the wells at this site for monitoring Site No. 18).

TABLE VI-1. (con't)

Site	Recommendation
No. 18, Old Burial Site (Category II)	- Install 2 additional groundwater monitoring wells: 1 deep upgradient 1 shallow upgradient - Sample 5 wells (1 existing, 2 from Site No. 19, 2 proposed) semiannually, and test for VOAs (Method 601). - If upgradient wells do not show contamination, install downgradient wells to define plume (based on best available information at the time).
No. 14, Drainage Ditch No. 2 (Category II)	- Install 3 additional groundwater monitoring wells: 2 deep downgradient 1 shallow upgradient - Incorporate the Phase II, Stage 3 deep upgradient well into the monitoring plan for this site. - Sample 6 wells (2 existing, 1 planned, 3 proposed) quarterly and test for VOAs (Method 601).
No. 13, Drainage Ditch No. 1 (Category II)	- Sample the well at this location semiannually and test for VOAs (Method 601). - Drill up to four soil borings to 40 feet to investigate the zone of possible perched water. No soil sampling will be required, but water samples should be collected if possible (analyze for VOAs).
No. 8, FPTA No. 1 (Category II)	- Install one additional shallow, upgradient groundwater monitoring well between the site and the base boundary. - Sample 2 wells (1 existing, 1 proposed) semiannually, and test for VOAs (Method 601).
No. 1, Runway Landfill (Category II)	- Install one additional deep groundwater monitoring well near MAFB-14 or 15. - Sample 3 wells (2 existing, 1 proposed) semiannually and test for VOAs (Method 601).

TABLE VI-1. (con't)

Recommendation	Cumulative Work
Proposed Shallow Wells:	6 (depths about 120')
Proposed Deep Wells:	7 (depths about 200')
Other Work:	Geophysical survey at Site No. 5 and Site No. 10 Soil borings (4 to 40-feet) at Site 13
Continued Monitoring:	19 existing wells 12 proposed wells 2 wells from Phase II, Stage 3
Sample analyses:	33 samples for VOAs (Method 601) plus perched water, if encountered

Stages 1 and 3. All additional wells drilled at Mather AFB should be drilled, constructed and sampled in accordance with California Site Mitigation Decision Tree Manual. Further, all deep wells must be designed and constructed to assure that they are properly sealed and that communication between aquifers is avoided.

The work performed in this project and the recommendations to be presented in this chapter are for IRP Phase II. AeroVironment recognizes that Phase II is not a complete assessment of environmental conditions at Mather AFB, and that new regulatory issues will require a more comprehensive assessment of sites as part of Remedial Investigations/Feasibility Studies (RI/FS). As the investigations at Mather AFB proceed into Phase IVA (equivalent to RI/FS) a wide range of additional study will be needed. This additional study will include source characterization, risk assessment (mini or full-scale), pump tests/aquifer testing and evaluation of remedial measures.

All of the sites at Mather AFB will require some level of Phase IVA study. For some of the sites, the work will probably be limited to some source sampling and a mini-risk assessment, while other sites will require a large amount of further study. However, all of this is outside the current scope of IRP Phase II and so our recommendations are limited to (1) a general recommendation that Phase IVA be initiated at all sites, and (2) site-specific Phase II action described below.

Area 1

Site 2 — "8150" Area Landfill — Category I

No further action is recommended at this site. No evidence of soil or groundwater contamination was found during either the drilling or water sampling phases. No threat to the surrounding environment is foreseen. However, the wells at this site may be used at a later date to help monitor contamination from Sites 3, 4 or 5.

Site 3 — Northeast Perimeter Landfill No. 1 — Category II

All three wells installed at Site 3 were found to be contaminated with PCE and other solvents. The concentrations of PCE exceeded DOHS action levels. AeroVironment recommends that three new wells be installed at this site. Two groundwater monitoring wells should be completed upgradient from the site, just inside the base boundary. The first, a deep well would be approximately 250 feet deep and should be installed in such a manner as to avoid mixing water from the water table and confined aquifer. The second, a shallow well, should be installed in the water table aquifer near the upgradient deep well. This well should be 90 to 100 feet deep. The upgradient wells are considered necessary to check the condition of groundwater entering the base near Site No. 3. The shallow upgradient well would help determine whether the source of PCE and other solvents is actually Site No. 3 or an off-base operation. In addition, one deep well should be installed near MAFB-26. MAFB-26 recorded the highest level of PCE of the three wells installed downgradient from Site 3. The combination of up- and downgradient deep wells will determine whether lower water-producing zones are also contaminated. Also, if contamination is identified the wells will help determine the source. The total estimated footage to be drilled is 600 linear feet. To be cost effective, the wells should be sampled twice a year and the water should be tested for volatile organics by EPA Method 601 only.

Site 4 — Northeast Perimeter Landfill No. 2 — Category II

As at Site 3, all three wells installed at Site 4 were found to be contaminated. MAFB-19 and 20 exceeded the PCE standard, while MAFB-21 exceeded PCE and DCE standards. One deep well is currently scheduled for installation upgradient of Site 4 as part of the Phase II, Stage 3 program. In addition, a properly constructed upgradient shallow well should be placed near MAFB-5, which was installed during Phase II, Stage 1. (MAFB-5 should be abandoned according to California well standards -- grouting to surface.) This new well should be 100 to 110 feet deep. It will provide information on the shallow water conditions upgradient from Site 4 (and Site 5). AV does not think MAFB-5 is providing accurate information about shallow groundwater conditions. As a result,

we are unable to determine the source(s) of PCE in MAFB-19, 20 and 21. In addition, one downgradient deep well should be placed near MAFB-19. The deep well should probably be screened from 230 to 250 feet. This well will help define conditions in lower aquifers in the vicinity of known contamination in the shallow waters. As with Site 3, all wells at Site 4 (existing and proposed) should be monitored twice yearly and the water should be tested for volatile organics by EPA Method 601 only.

Site 5 — Northeast Perimeter Landfill No. 3 — Category II

One of the two wells at Site 5 showed small concentrations of the same compounds found at Sites 3 and 4. It is suspected that the contamination in MAFB-23 is the result of other on-base or off-base sources. To help define the problem, it is recommended that MAFB-22 and 23 continue to be monitored semi-annually for volatile organics, using EPA 601 analysis.

During the geophysical portion of this study, a shallow conductive plume was found to be travelling south from Site 5. Because of access problems, AV could not follow the plume to its conclusion. It is *recommended* that this plume be traced inside the RV storage area (where AV did not go) using the electrical conductivity method. If this plume is discovered to bypass the current set of shallow wells, then a third shallow well should be installed to intercept and monitor the plume.

Area 2

Site 6 — Firing Range Landfill — Category I

No further action is recommended for Site 6, as no evidence of environmental contamination has been found.

Site 17 — Weapons Storage Area Septic Tank — Category I

No further action is recommended for Site 17, as no evidence of environmental contamination has been found. (MAFB-27B should not be abandoned, even

though it is currently dry, so that it can be used for water level measurements in high water level periods).

Area 3

Site 20 — MOGAS Spill Site — Category I

Since no evidence of groundwater contamination was found at Site 20, we do not recommend any further action.

Site 11 — Existing Fire Protection Training Area (1958-1984) — Category I

No evidence of groundwater contamination was found at Site 11 and no further action is recommended for the FPTA. However, MAFB-39 (installed to monitor Site 11) is located very close to Site 7, which was studied as part of Phase II, Stage 1. If groundwater flow direction in the area of Site 11 shifts toward the west, then MAFB-39 could be used as part of the monitoring network being installed at that site under Phase II, Stage 3 to help monitor the 7100 area Landfill, Site 7.

Area 4

Site 10 (A & B) — Fire Protection Training Area No. 3 — Category II

Low levels of TCE were found in both MAFB-36 and 37. These levels were significantly below the DOHS action level of 5.0 ppb. It is recommended that continued monitoring be performed only for the existing wells. No additional well installations are necessary. MAFB-36 and 37 should be tested twice yearly. The contaminant in question is TCE, so the water samples should be tested for volatile organics using EPA Method 601.

In addition, we recommend that an effort should be made to determine (to a depth of 10 feet) the cause of the magnetic anomaly at Site 10A. This effort

should initially include additional geophysical investigation. If this is successful, 10-foot soil borings could be used to confirm the presence of the anomaly.

Site 19 — Fuel Tank Sludge Burial Site — Category I

Soil and groundwater samples taken at Site 19 did not show any indication of contamination. Additional work at this site is not recommended. However, the wells at this site should be used as part of the monitoring network for Site 18.

Site 18 — Old Burial Site — Category II

MAFB-33, downgradient from Site 18, had the highest TCE concentrations of any well installed during the Phase II, Stage 2 effort. TCE was found at 10 times the DOHS action level. With that in mind, AeroVironment recommends that two additional wells be drilled upgradient from the site to better characterize water entering the site. One well should be drilled to the water table aquifer, about 90 feet in this area, and the second should be installed in the first confined aquifer, at approximately 200 feet. These two wells should be installed about half way between Site 18 and Site 14 (also showing TCE contamination). If, after installation, the new upgradient wells are found to be free of TCE contamination, additional downgradient wells will be necessary. Any additional downgradient wells would be positioned after review of all well logs which exist at that time.

MAFB-34 and 35 (Site 19) are located downgradient from the contaminated well at Site 18. MAFB 34 and 35, along with MAFB-33 and the two proposed wells, should be monitored twice a year to check the movement of contamination identified in this area. Samples should be analyzed for volatile organics using EPA Method 601.

Area 5

Site 14 — Drainage Ditch Site No. 2 — Category II

High levels of TCE were found in one of the two wells installed downgradient from Site 14. These wells were installed to provide an early warning of shallow plumes that possibly were migrating toward base water supply wells MB-2 and MB-3. Due to the critical need for a clean water supply on base, we would recommend that two deep monitoring wells be installed between Site 14 and the base supply wells. We also recommend that a shallow upgradient well be installed between Site 14 and the base boundary. This well would provide better upgradient information than the existing well further north (MAFB-6). This shallow well would be paired with a deep upgradient well currently planned for Phase II, Stage 3. The deep well between the site and MB-3 should be screened from 300 to 320 feet. This is the level of the first perforations in MB-3. The second deep well should be upgradient from MB-2. It should be screened between 190 and 210 feet to match the screen in MB-2. All monitoring wells at this site should be analyzed for TCE (EPA Method 601) quarterly. Quarterly sampling is recommended for two reasons: (1) to coincide with quarterly base production well sampling, and (2) because of the concern that wells near this site could be a precursor to production well contamination.

Site 13 — Drainage Ditch Site No. 1 — Category II

The well at Site 13 was found to contain PCE, TCE and DCE; however, none of the compounds were above the DOHS action level. The contamination is thought to be resulting from other base or off-base sources. AeroVironment recommends continued monitoring of Site 13, sampling twice yearly, and analyzing the water sample according to EPA Method 601. The sampling will help track the plume of PCE/DCE/TCE which is present in the northeast correr of Mather AFB. MAFB-12, which was installed to monitor Site 8, can be used as an upgradient monitoring point for Site 13.

A possible zone of perched water was noticed during the drilling of MAFB-13. If perched water does exist under this site, it would be investigated to determine what, if any, contaminatns exist in the water. AV recommends drilling up to four soil borings (hollow stem) to a maximum of 40 feet. If water is encountered in the borings during drilling it should be collected and analyzed for volatile organics using EPA Method 601.

Site 8 — Fire Protection Training Area No. 1 — Category II

MAFB-12 was found to be contaminated with PCE and other solvents. All levels were under the DOHS action levels. To better characterize the water that is entering under the base from upgradient locations, it is recommended that one shallow well be drilled to the water table just inside the base boundary, northeast of Site 8. The FPTA is located along the northern boundary of Mather AFB and is the most upgradient site in Area 5. Without upgradient wells, we cannot determine if the FPTA is really the source of MAFB-12 contamination.

The new well and MAFB-12 should be sampled twice yearly and the water samples analyzed for PCE, TCE, DCE, etc. using EPA Method 601. It is recommended that MAFB-12 also be used to provide upgradient water quality information for Site 13.

Site 1 — Runway Overrun Landfill — Category II

Both wells installed at Site 1 are contaminated with PCE, DCE, TCE and 1,2-Dichloropropane. However, no information is available on conditions upgradient of the site, or in lower water-bearing zones. It is recommended that a deep well be installed beside the runway overrun near MAFB-15 to characterize deep-water conditions. Water moving onto the base from upgradient sources will be checked by a set of upgradient deep and shallow wells which were previously recommended for Sites 3, 4, and 14. MAFB-14 and 15, along with the new deep well should be sampled twice each year and analyzed for volatile organics using EPA Method 601.

In addition to the periodic monitoring of specific wells, all of the monitoring wells (Stage 1 and 2) should have the static water levels measured once in the Spring and once in the Fall. Groundwater contours should then be constructed to check flow patterns. If regional patterns change due to increased or decreased groundwater extraction in the farming areas near the base, then the present downgradient monitoring well network for some sites may be inadequate. As the areas around the base become more urbanized, this may become a major consideration for long-term monitoring programs.

APPENDIX A

Definitions, Nomenclatures and Units of Measurement

A. DEFINITIONS, NOMENCLATURES AND UNITS OF MEASUREMENT

ACUREX: Laboratory selected to analyze samples collected during field investigation at Mather Air Force Base.

AF: Air Force.

AFB: Air Force Base.

AIR-ROTARY DRILLING: A method for boring holes in the earth employing air rather than water to remove cuttings from the hole.

ALLUVIUM: Materials eroded, transported and deposited by streams.

ANOMALY: A local feature distinguishable in a geophysical measurement.

AQUICLUDE: Poorly permeable formation that impedes groundwater movement and does not yield to a well or spring.

AQUIFER: A geologic formation, group of formations, or part of a formation that is capable of yielding water to a well or spring.

AQUITARD: A geologic unit which impedes groundwater flow.

AROMATIC: Description of organic chemical compounds in which the carbon atoms are arranged in a ring associated with special electron stability. Aromatic compounds are often more reactive than nonaromatics.

ARTESIAN: Groundwater contained under hydrostatic pressure.

AV: AeroVironment Inc.

AVGAS: Aviation Gasoline.

BAILER: A tubular piece of equipment with a check valve at one end consisting of a simple ball and seat arrangement. it is lowered down a well via a rope and pulley system to collect well water samples.

BEE: Bioenvironmental Engineer

BENTONITE: A clay formed from the decomposition of volcanic ash which has great ability to absorb or adsorb water and to swell accordingly. It is commonly used to seal a groundwater well in a nonscreened area.

BES: Bioenvironmental Engineering Services.

BIODEGRADABLE: The characteristic of a substance to be broken down from complex to simple compounds by microorganisms.

BLS: Below land surface.

BLIND DUPLICATE: A field replicate sample submitted to a laboratory as a routine sample for analysis without any identification as a quality control sample. The purpose of blind duplicate samples is to monitor sampling and analytical precision without the introduction of laboratory bias.

BNA: Base/neutral, acid fraction of priority pollutants.

BRAIDED STREAM: A stream flowing in several dividing and reuniting sections, the cause of the division being the obstruction by sediment deposited by the stream.

CAPILLARY FRINGE: The zone overlying the saturated zone containing capillary interstices which may be filled with water.

Cd: Chemical symbol for cadmium.

CHAIN-OF-CUSTODY: The documentation of sample possession, beginning at collection and ending at analysis. A chain-of-custody form accompanies samples and records the data and time of each sample possession transfer.

CHRISTIE BOX: A small reinforced concrete box with locking steel cap which is cemented to the ground. It is used to complete a well at the surface so that the top is flush to the ground.

CLAY: A sediment particle having a diameter less than 1/512 mm.

CONDUCTIVITY: A property of an electric conductor defined as the electrical current per unit area divided by the voltage drop per unit length.

CONFINED AQUIFER: An aquifer bounded above and below by impermeable strata or by geologic units distinctly less permeable than the aquifer itself.

CONFINING UNIT: An aquitard or other poorly permeable layer which restricts the movement of groundwater.

CONSOLIDATION: The adjustment of a saturated soil in response to increased load. Involves the squeezing of water from the pores and decrease in void ratio.

CONTAMINATION: The degradation of natural water quality or soil to the extent that its usefulness is impaired. This term does not imply any specific limits, since the degree of contamination which is permissible depends on the end use for which the water is intended.

CONE OF DEPRESSION: The depression produced in a water table or piezometric surface by pumping or artesian flow.

Cr: Chemical symbol for chromium.

Cu: Chemical symbol for copper.

DBCP: Dibromochloropropane.

DH: Drill hole.

DIELECTRIC CONTRAST: A contrast between conducting materials and non-conducting materials.

DISPOSAL FACILITY: A facility or part of a facility at which hazardous waste is intentionally placed into or on land or water, and at which waste will remain after closure.

DISPOSAL OF HAZARDOUS WASTE: The discharge, deposit, injection, dumping, spilling, or placing of any hazardous waste into or on land or water so that such waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including groundwater.

DoD: Department of Defense.

DOHS: *California Department of Health Services.*

DOWNGRADIENT: In the direction of decreasing hydraulic static head; the direction in which groundwater flows.

DRILLING: Air rotary drilling.

DRINKING QUALITY WATER: *Water meeting primary drinking water standards.*

DRIVE CASING: A casing which is driven into a bore hole to prevent caving.

DUMP: An uncovered land disposal site where solid and/or liquid wastes are deposited with little or no regard for pollution control or aesthetics. Dumps are susceptible to open burning and are exposed to the elements, disease vectors and scavengers.

EDB: Ethylenedibromide

EFFECTIVE PRECIPITATION: The mean annual precipitation minus the mean annual evaporation.

ELECTROMAGNETIC SURVEY: A geophysical method employing electromagnetic waves at the earth's surface. When waves impinge on a conducting formation or saturated soil, they induce currents that are detected by an instrument at the surface.

EM: Electromagnetic survey.

EOCENE: Strata of the Tertiary era, between the Paleocene and Oligocene.

EPA: U.S. Environmental Protection Agency.

E.P. TOXICITY: Extraction procedure toxicity, one criteria for determining whether a material is a hazardous waste. The E.P. toxicity test is a leachate simulation established by EPA to determine whether toxic material will leach from the waste over time. The test method is specified in 40 CFR 261, Appendix II.

EROSION: The wearing away of land surface by wind, water, or chemical processes.

EXPLOSIMETER: Monitoring device for detecting explosive gases in ambient air by reading percent of lower explosive limit.

FIELD BLANK: A blank sample that is kept in the sample storage area throughout the sampling activities. After activities are over, this smple is analyzed to see whether the storage environment has introduced contaminants to the samples.

FLOOD PLAIN: The lowland and relatively flat areas adjoining inland and coastal areas of the mainland and off-shore islands, including, at a minimum, areas subject to a one percent or greater chance of flooding in any given year.

FLOW PATH: The direction or movement of groundwater as governed principally by the hydraulic gradient.

FLUVIAL: Of, or pertaining to rivers; produced by river action.

FPTA: Fire Protection Training Area.

GC/MS: Gas chromatograph/mass spectrometer, a laboratory instrument for separating and identifying unknown organic compounds.

GEOPHYSICAL SURVEY: The exploration of an area in which geophysical properties and relationships unique to the area are mapped by one or more methods.

GPR: Ground Penetrating Radar.

GRAVEL: A collective term for sediments whose particle sizes are greater than 2 mm.

GRAVEL PACK: A gravel of particular size used to encase the area of the well through which the groundwater enters. In this way, it acts as a conduit for the groundwater.

GROUND PENETRATING RADAR: A method used in a geophysical survey which uses radar transmissions to detect a boundary between media with different electrical and physical properties in order to locate buried objects and estimate the thickness of landfill covering layers.

GROUNDWATER: Water beneath the land surface in the saturated zone that is under atmospheric or artesian pressure.

GROUNDWATER RESERVOIR: The earth materials and the intervening open spaces that contain groundwater.

HARM: Hazard Assessment Rating Methodology.

HAZARDOUS SUBSTANCE: Under CERCLA, the definition of hazardous substance includes:

1. All substances regulated under Paragraphs 311 and 307 of the Clean Water Act (except oil)

2. All substances regulated under Paragraph 3001 of the Solid Waste Disposal Act

3. All substances regulated under Paragraph 112 of the Clean Air Act

4. All substances which the Administrator of EPA has acted against under Paragraph 7 of the Toxic Substance Control Act

5. Additional substances designated under Paragraph 102 of the Superfund bill

HAZARDOUS WASTE: As defined in RCRA, a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical or infectious characteristics may cause or significantly contribute to an increase in mortality or an increase in serious, irreversible, or incapacitating reversible illness; or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

HAZARDOUS WASTE GENERATION: The act or process of producing a hazardous waste.

HEAVY METALS: Metallic elements, including the transition series, which include many elements required for plant and animal nutrition in trace concentrations but become toxic at higher concentrations.

HOLDING TIME: The amount of time after sampling in which a sample must be analyzed or extracted, according to the EPA.

HOLLOW STEM AUGER: A method by which drilling is accomplished by rotating the hollow stem augers into the soils. An auger's design is similar to a large screw with protruding flights replacing the screw's threads. As augers are "screwed" into the soils, the cuttings are brought to the surface on the rotating flights.

HYDROCARBONS: Organic chemical compounds composed of hydrogen and carbon atoms chemically bonded. Hydrocarbons may be straight chain, cyclic, branched chain, aromatic, or polycyclic, depending upon arrangement of carbon atoms. Halogenated hydrocarbons are hydrocarbons in which one or more hydrogen atoms has been replaced by a halogen atom.

I.D.: Inside diameter.

IGNEOUS: Formed by solidification from a molten or partially molten state.

INDURATED: Sediments hardened by heat, pressure or natural concentration.

INFILTRATION: The movement of water through the soil surface into the ground.

IRP: Installation Restoration Program.

JP-4: Jet Propulsion Fuel Number Four, military jet fuel.

LEACHATE: A solution resulting from the separation or dissolving of soluble or particulate constituents from solid waste or other man-placed medium by percolation of water.

LEACHING: The process by which soluble materials in the soil, such as nutrients, pesticide chemicals or contaminants, are washed into a lower layer of soil or are dissolved and carried away by water.

LINER: A continuous layer of natural or man-made materials beneath or on the sides of a surface impoundment, landfill, or landfill cell which restricts the downward or lateral escape of hazardous waste, hazardous waste constituents or leachate.

LITHOLOGY: The description of the physical character of a rock.

LOAM: A soil composed of a mixture of clay, silt, sand and organic matter.

MAFB: Mather Air Force Base groundwater monitoring well.

MB: Main Base water production well.

MAGNETOMETER SURVEY: A measurement of magnetic intensity in an area of earth.

MEHRTEN FORMATION: A stratigraphic section comprised of volcanic-derived angular gravels and sand, dark mafic rock fragments, mudflows. It is discontinuous, with abundant cross-bedding and cut-and-fill structures.

MEK: Methyl Ethyl Ketone.

MESOZOIC: One of the eras of geologic time, following the Paleozoic and succeeded by the Cenozoic era.

METALS: See "Heavy Metals."

METAMORPHIC: Segregation of certain minerals into lenses and bands accomplished by altering rock composition, texture and internal structure through pressure, heat and the introduction of new chemical substances.

MOGAS: Motor gasoline.

MONITORING WELL: A well used to measure groundwater levels and to obtain samples.

MSL: Mean Sea Level.

MUD ROTARY DRILLING: A drilling method for boring holes in the earth that employs water to remove cuttings from the hole.

NONINTRUSIVE: Method of investigation in which information may be gained without disturbing the object being investigated.

OD: Outside diameter.

O_2: Oxygen molecule.

OEHL: Occupational and Environmental Health Laboratory.

O&G: Symbols for oil and grease analysis.

ORGANIC: Being, containing or relating to carbon compounds, especially in which hydrogen is attached to carbon.

OVM: Organic vapor meter.

OXYGEN DEFICIENCY: This occurs when air contains less than 16% oxygen, insufficient to support human life.

PALEOZOIC: The group of rocks deposited during the era between the Late Precambrian and Mesozoic eras.

Pb: Chemical symbol for lead.

PCB: Polychlorinated Biphenyl; liquids used as a dielectrics in electrical equipment.

PCE: Tetrachloroethene (Perchloroethylene).

PERCHED WATER TABLE: A water table above a relatively impermeable zone underlain by unsaturated rocks of sufficient permeability to allow groundwater movement.

PERCOLATION: Movement of moisture by gravity or hydrostatic pressure through interstices of unsaturated rock or soil.

PERMEABILITY: The capacity of a porous rock, soil or sediment for transmitting a fluid without damage to the structure of the medium.

PERSISTENCE: As applied to chemicals, those which are very stable and remain in the environment in their original form for an extended period of time.

PESTICIDE: An agent used to destroy pests. Pesticides include such specialty groups as herbicides, fungicides, insecticides, etc.

pH: The negative logarithm of the hydrogen ion activity that indicates the acidity or basicity of a sample.

PHENOL: Total recoverable phenolics -- any of various acidic compounds analogous to phenol and regarded as hydroxyl derivatives of aromatic hydrocarbons.

PLUME: The spreading of a contaminant in a fanning-out manner from the source.

POL: Petroleum, Oil and Lubricants.

POLLUTANT: Any introduced gas, liquid or solid that makes a resource unfit for a specific purpose.

POTENTIOMETRIC SURFACE: The imaginery surface to which water in an artesian aquifer would rise in tightly screened wells penetrating it.

PPB: Parts per billion by weight, equivalent to ug/kg, or µg/l for water.

PPM: Parts per million by weight, equivalent to µg/g, or mg/l for water.

psi: Pounds per square inch.

PRECIPITATION: Rainfall.

QA/QC: Quality assurance/quality control.

RCRA: Resource Conservation and Recovery Act.

RECEPTORS: The potential impact group or resource for a waste contamination source.

RECHARGE: The addition of water to the groundwater system by natural or artificial processes.

RECHARGE AREA: A surface area in which surface water or precipitation percolates through the unsaturated zone and eventually reaches the zone of saturation. Recharge areas may be natural or man-made.

RECORDS SEARCH: The IRP Records Search for Mather Air Force Base, compiled and written by CH2M-Hill.

RESISTIVITY: A factor of the limit to a steady electric current in a conductor that depends upon the material and its physical condition.

RFB: Request for bids.

RING SAMPLE: A soil sample taken with a two-inch diameter tubular ring.

SAC: Strategic air command.

SAND: Particles of sediment having diameters larger than 1/16 mm (62 microns) and smaller than 2 mm.

SANITARY LANDFILL: A land disposal site using an engineered method of disposing solid wastes on land in a way that minimizes environmental hazards.

SATURATED ZONE: That part of the earth's crust in which all voids are filled with water.

SCS: U.S. Department of Agriculture Soil Conservation Service.

SILT: Sediment particles having diameters larger than 1/512 mm (2 microns) and smaller than 1/16 mm (62 microns).

SLUDGE: The solid residue resulting from a manufacturing or wastewater treatment process that also produces a liquid stream.

SOLID WASTE: Any garbage, refuse, or sludge from a waste treatment plant, water supply treatment, or air pollution control facility and other discarded material, including solid, liquid semisolid, or contained gaseous material resulting from industrial, commercial, mining, or agricultural operations and from community activities. This does not include solid or dissolved materials in domestic sewage, solid or dissolved materials in irrigation return flows, industrial discharges which are point sources subject to permits under Section 402 of the Federal Water Pollution Control Act, as amended (86 USC 880), or source, special nuclear, or by-product material as defined by the Atomic Energy Act of 1954 (68 USC 923).

SOW: Statement of work.

SPECIFIC RETENTION: The ratio of (1) the volume of a liquid which, after being saturated, will retain against the pull of gravity to (2) its own volume. It is stated as a percentage.

SPIKE: A quality control check consisting of a chemical or solution of a known concentration presented to the lab for analysis as an unknown, or the addition of a known quantity of analyte to a sample by the analyst to assess method accuracy.

SPILL: Any unplanned release or discharge of a hazardous substance onto or into the air, land, or water.

SPLIT SAMPLE: A second sample taken from the same site as the original sample to assess sampling and/or laboratory precision; a duplicate sample.

STORAGE OF HAZARDOUS WASTE: Containment, either on a temporary basis or for a longer period, in such a manner as not to constitute disposal of such hazardous waste.

SWL: Static water level.

TCE: Trichloroethene.

TOXICITY: The ability of a material to produce injury or disease upon exposure, ingestion, inhalation, or assimilation by a living organism.

TREATMENT OF HAZARDOUS WASTE: Any method, technique, or process, including neutralization, designed to change the physical, chemical, or biological character or composition of any hazardous waste so as to neutralize the waste or render it nonhazardous.

UNSATURATED ZONE: Zone above the water table. Most of the time, the pore space between soil particles in this zone is filled with air, except near grain-to-grain boundaries where surface tension maintains a film of water between the particles.

UPGRADIENT: In the direction of increasing hydraulic static head; the direction opposite to the prevailing flow of groundwater.

USAF: United States Air Force.

USGS: United States Geological Survey.

VICTOR FORMATION: A stratigraphic section comprised of heterogeneous fluvial clay-to-gravel sediments. It also contains lenticular deposits from banded streams and is mostly made up of silty sand.

VOA: Volatile organic analysis, purgeable fraction of priority pollutants.

VOLATILE COMPOUNDS: Those materials whose vapor pressures are sufficiently high such that they may become concentrated in any gaseous phase that forms; readily vaporizable.

WATER TABLE: Surface of a body of unconfined groundwater at which the pressure is equal to that of the atmosphere.

WELL DEVELOPMENT: The process by which a well is swabbed and pumped until the water produced is free of sediment.

WELL SCREEN: The portion of the well casing which is situated in the water-bearing strata and contains .02-inch slits to allow groundwater to enter the well.

WDC: Water Development Corporation.

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